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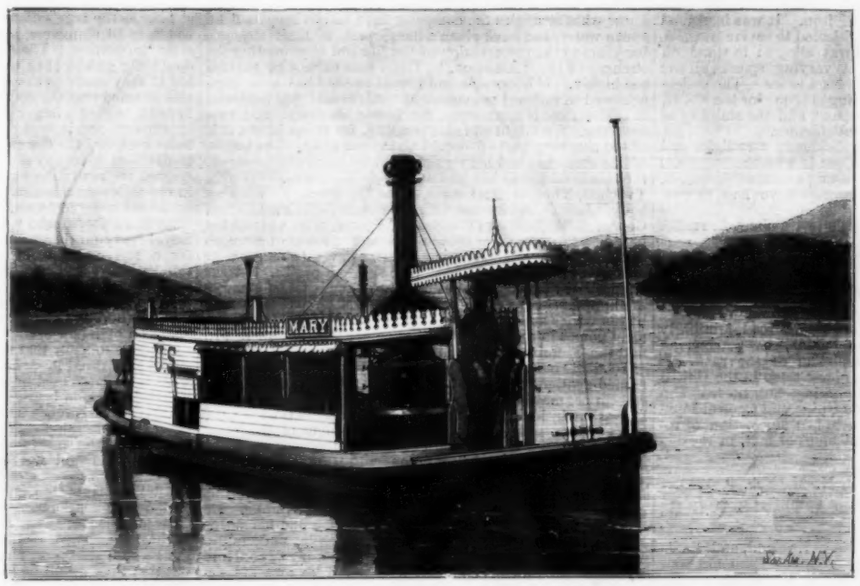
LIGHT DRAUGHT STERN WHEEL STEAM YACHT.

In our SUPPLEMENTS, Nos. 172 and 179, we gave three pages of working drawings illustrating the construction of light draught stern wheel steam yachts as built at the U. S. works, Rock Island, Ill., by M. Meigs, U. S. Civil Engineer, under the direction of Col. J. W. Farquhar.

The light draught of these boats, economy of construction, and speed, render them very desirable boats for shallow waters.

For example, the draught is only 16 inches, length of hull 84 ft., beam 8 ft. 2 in., wheel 6 ft., engine cylinders 4½ in., boiler 30 in. diameter, 60 in. high, horse power 7 2-10.

We present herewith a perspective view of one of these boats, the Mary, lately built at Rock Island, as above mentioned, for the use of the U. S. surveying parties in the Upper Mississippi river, which has been tried with much success. We refer the reader for the full details of construction, measurements, and other dimensions to the SUPPLEMENT numbers above mentioned.



LIGHT DRAUGHT STERN WHEEL STEAM YACHT.

SMALL STEAM LAUNCH.

We illustrate below a steam launch for passenger traffic, constructed by Messrs. Miller & Tupp, of Hammersmith. The little craft was built to a specification, of which the following is an abstract: Hull—length over all, 40 ft.; draught, 3 ft.; beam outside, 7 ft.; depth inside of skin to gunwale, 3 ft. 6 in.; to be strong and substantial carvel built, of teak, copper fastened and sheathed, with keel, and main timbers of oak or American elm; to have swan stem and counter stern; to be lined with teak down to the benches, and to have cuddy deck at each end of the boat, with doors to form lockers; seats to be arranged fore and aft, with cross benches in stern sheets and forward of boiler; coal bunkers amidships on each side of boiler; rudder to be fitted outside propeller, with galvanized iron tiller. Engine to be pair vertical inverted cylinder, direct-acting high-pressure type, 5¾ in. diameter by 6 in. stroke, of simple and substantial construction, thoroughly well fitted and finished with large bearing surfaces, the means of lubrication carefully attended to, and fitted with link-motion reversing gear, and feed pump of ample size. Boiler to be of the vertical cross-tube type, 3 ft. 6 in. diameter by 4 ft. 6 in. high, with four tubes; to be very strongly constructed, and tested by hydraulic pressure to 150 lb. per square inch, and designed to work at 60 lb.; to be neatly felted and lagged with mahogany and brass bands, and to be fitted with all necessary furnace and steam mountings, spring balance safety valve with escape pipe, steam pressure gauge with double dial facing fore and aft, double set of water gauges, blow-off cock, steam whistle, blower cock, and hinged chimney. Propeller to be of steel, 36 in. diameter; screw shaft of wrought iron, 1⅞ in. diameter; gun-metal bushed to stern tube, and fitted with thrust bearing and collar. Connections—copper steam and feed pipes, and iron exhaust pipe.
—*The Engineer.*

THE SEVERN BRIDGE.

THE completion of the fine bridge or viaduct across the Severn is interesting as a triumph of engineering skill, and also as another step toward uniting more closely the Midland counties and the Welsh coal-fields, and the latter district with the metropolis.

Prior to the erection of this bridge there was no permanent communication between the two banks, until Gloucester—which is nearly 50 miles from the mouth of the estuary—was reached.

The Severn Bridge is, says the *Universal Engineer*, with one exception, the longest in the United Kingdom, the exception being—as most of our readers are aware—the Tay Bridge, to which so large a share of public attention has been lately drawn.

The Severn Bridge has been built in four years, at a cost of £200,000; and, taking into consideration its length—three-quarters of a mile, its height above high water—70 ft., the width of the spans, etc., it will be found to compare favorably, in time and cost, with other structures of a similar character.

The Severn Bridge Railway, five miles in length, commences at Lydney by a junction with the Great Western and Severn and Wye Railways, crosses the River Severn near Purton Passage, and terminates at the Sharpeness Docks by a junction with the Midland Railway. It shortens the distance from South Wales to Bristol by 30 miles; and if a junction half a mile in length were made at Stonehouse between the Midland and Great Western, it would shorten the distance from South Wales to London by 14 miles. The railway is partly single and partly double, the land has been inclosed for a double line, and all the works, except the bridge over the Severn, have been constructed for a double line.

The total length of the bridge is 4,162 ft. It consists of 22 spans, varying in length from 134 ft. to 327 ft., and in depth from 16 to 38 ft., as follows: One span 134 ft. long; two spans 327 ft. long; five spans 171 ft. long; 13 spans 134 ft. 6 in long; and the swing bridge 197 ft. in length.

The 21 bow-shaped girders rest on iron cylindrical pillars filled with concrete, similar to those of the Tay Bridge.

The cylinders were sunk by excavating from the inside and weighting on the top, the depth of sand at the first 12 piers averaging about 28 ft. After pier No. 12 had been completed, compressed air was employed, the pressure maintained varying from 5 lb. to 40 lb., according to the depth of foundation. Owing to the tide and current, and the yielding nature of the sand, very considerable difficulty was encountered in securing the scaffolding, first for the piers, and afterward for the girders. This was especially the case with piers Nos. 14 and 15, the staging, together with the piers, having been carried away on one occasion by the force of the tide, which rises 30 ft. in 2½ hours, and has a current of 10 knots an hour. Piers Nos. 15 to 20 also caused great difficulty. Over this distance the depth from high water to the bed rock was 70 ft. The sand had here been scoured away until only about 10 ft. remained, having a depth of water of 30 ft. at low tide. Fortunately there was a layer of gravelly clay overlying the rock at this part of the river, which afforded firm hold for the piles of the staging.

Owing to the sand banks, the great velocity of the current, and the great rise and fall of tide, it was impracticable—or would have involved too great a risk—to adopt the mode of erection used on the Tay Bridge, viz., building the girders on shore, floating them to the site, and lifting them into position. It was absolutely necessary in this case to resort to scaffolding, so as to erect the girders on a platform in their position. In the smaller spans one temporary scaffold-pier was built in the center of the opening, and trusses used to bridge the intermediate spaces, which were then planked over to form a continuous platform. In the larger spans it was found necessary to erect three temporary scaffold piers, which, owing to their great base of 150 ft. in the greatest run of tide, were very elaborate specimens of timber work, containing no less than 60,000 cubic feet.

It would have been an extremely difficult matter, involving several months' delay, to erect the scaffolding in such a tideway without the aid of the electric light, which proved to be of great service in this work. It enabled the work to be carried on every tide, and gained the safe erection of the large span before the autumnal tide. It was, indeed, found impossible to throw sufficient light with the fire-baskets (known among the workmen as "devils"), or with coal and petroleum lamps, to moor the pile-driving barges, and to enable the men to work on the scaffold with safety at night. The Pyramid Electric Light Company supplied the machines and lamps, which, after the first fortnight, worked without a hitch and were in every sense satisfactory, thus supplying the great want of adequate light.

The arrangement of the girders is very simple. The top and bottom members are connected by verticals which carry the cross-girders from the roadway. Small longitudinal girders between the cross-girders are fixed to carry the rails, and the floor is filled up with plate-iron decking. This form of girder has a more pleasing appearance than the straight lattice girder, like those used in the Tay Bridge, and is very little affected by wind. Across the navigable portion of the stream the spans are, of course, wider than at the shallower parts. The first span on the Lydney side is 134 ft. 6 in., then follow two of 327 ft., under which the large shipping passes; the next five are 171 ft., and the remaining 13 are 134 ft. spans. The two large spans of 327 ft. each are believed to be the widest bowstring spans in England. The depth of the girders in the center is 38 ft.

On the Lydney side, where it approaches the shore, the roadway is carried to the high-level land by means of a viaduct of 12 arches, 70 ft. high, constructed of Forest stone, which is a splendid piece of

SMALL STEAM SCREW LAUNCH.

masonry. On the south side special provision had to be made for allowing the large vessels that pass up the Gloucester and Berkeley Canal to pass the site of the bridge. The structure, therefore, terminates on this side with a massive swing bridge, which is 500 tons in weight and about 197 ft. long. It has a double opening, and rests upon a strong circular tower of heavy masonry. One of the openings of this swing bridge is across the canal, and the other over the adjoining shore of the river. This arrangement of the bridge swinging on its center insures an even balance and a minimum of friction in turning. It turns upon a table of rollers known technically as a "live ring," and the motive power is supplied by a steam engine inclosed in an engine house on the top of the girders. The engine, as well as the machinery for turning the bridge, is so arranged that there shall always be a reserve boiler-engine and machinery to provide for repairs or any sudden breakdown. Friction-gear transmits the power from the engine to the machinery for turning or locking, and this is so arranged that the turning and locking cannot be in gear at the same time. The locking is effected by large iron wedges, driven by steam right and left at both ends of the bridge, lifting the bridge and causing it to take a solid bearing on the piers. Moving simultaneously with the wedges is an iron bar, sharply pointed at the end, which, as it advances, enters a socket in the pier and so trims the rails to a nicety. An indicator in the engine house, with a warning bell, shows the driver how far he can drive the wedge. The indicator is also used as a means of severing the telegraphic connection, so that the bridgeman cannot signal a train to cross the bridge unless the bridge is closed and locked.

The bridge contains 7,000 tons of iron. It was inspected by Colonel Rich, R.E., and was subjected to severe tests. A train of eight heavy locomotives was allowed to stand on each girder, and then run over at varying speeds, all the girders of the spans being tested at least twice. The deflections recorded were moderate, being 1¼ in. for the 827 ft. spans, and ⅝ in. for the smaller spans, and the stability of the whole structure proved to be satisfactory.

The whole effect of the Severn Bridge is very light and elegant, and must impress all who see it with the immense difficulties against which the consulting engineer, Mr. T. E. Harrison, M.I.C.E., and the contractors have had to contend.

The total cost of the bridge, together with about five miles of railway, was £400,000.

THE "BOSTON PACIFIC."

THE Atchison, Topeka, and Santa Fe Railroad, familiarly known in the West as "the Boston Pacific," has reached the capital of New Mexico. The completion of the road has been celebrated in that next to the oldest town in the United States by ceremonies a little less imposing, but no less significant, than those with which the Union and Central Pacific roads were united in 1869. There is a suggestion of romance and poetry, as well as a statement of fact, in the dispatch of Governor Anthony:

SANTA FE, N. M., Feb. 9, 1880.

HON. THOMAS NICKERSON, President A. T. and S. F. R. R., Boston:

New Mexico sends greeting to New England, and Santa Fe to Boston. An enterprise long credited to you and your associates as the dream of speculators is to-day an accomplished fact. Atchison, Topeka, and Santa Fe are united by an unbroken band of iron and a continuous path of commerce. The last rail has been laid, and, at 11 o'clock this morning, the last spike driven by Governor Wallace, in the presence of the territorial legislature and officers. The military and entire populace, salvos of artillery, music of bands, locomotive whistles, and the cheers of thousands of spectators welcomed the joyous event. You have to-day what you have so well earned—the gratitude of this people.

(Signed) GEORGE T. ANTHONY.

Santa Fe was a "populous pueblo" when first visited by the Spaniards under the Cordovan Espigo, in 1540, and has been the capital of New Mexico since 1640. It was a city when Boston was a baby, but the baby town of 1640 now supplies the old capital with its first and only railroad communication with the great commercial world. Grateful is the greeting which the telegraph brings. But the old capital, corraled in the mountains, is only a way station on the great through line of the "Boston Pacific," whose passenger station will be a better building than "The Palace of the Pueblos," of which Mrs. General Wallace has just written an interesting account.

The completion of the Atchison, Topeka, and Santa Fe road to Santa Fe suggests a review of the company's history, which can but be a source of pride to every citizen of Boston. The company, in 1870, was much like a European hotel, imposing chiefly in name. It had 62 miles of road, extending from Topeka to Emporia. Its gross receipts were $182,580. In 1880 it has 1,152 miles of road, and its receipts for the year just closed were $6,338,447. Its earnings per mile in 1870 were $2,945, in 1879 $5,502. It now extends from the Missouri to the Rio Grande, and before 1883 will probably extend to San Francisco; will have a line to Guaymas on the Gulf of California, and may be running Pullman cars into the city of Mexico. It seems, judging by the projected routes, bound to be the longest railroad, under one management, in the world. Its past, remarkable as it is for prosperity, will be eclipsed by its future. Its greatest difficulties have been surmounted. A careful preservation of the credit for economy and honesty which the company has earned, with a continuance of the energy and wisdom which have characterized the present and past managers, will make the future success of the great enterprise certain. The stock of the company has been a bonanza to hundreds here and elsewhere, but the mine is as yet only "just opened." With its small indebtedness and enormous earnings, in the near future certain to be much greater than ever, it cannot fail to be immensely profitable to its owners. But we are speaking of its future; we started out to speak of its past and present.

The company received its charter March 3, 1863. The road was to be completed to the western boundary of Kansas March 3, 1873. Six years passed before anything was done. At the close of 1871 there remained to be built 350 miles of road, and only a year to build it in. Five millions of dollars must be secured, and other difficulties presented themselves. An appeal was made to Congress for an extension of time for two years longer, but no extension was secured, and the board determined to push ahead the work. The road was completed within the time named in the charter. Three hundred and sixty miles of road were built in 260 days, and well built, too. Cars ran to the Colorado line before Dec. 30, 1872. In 1873–4 the Pueblo and Arkansas Valley Railroad was built by the Atchison people, and thus the company had a road of its own from the Missouri River to the Rocky Mountains. An eastern outlet, besides that at Atchison, was obtained by lease of the Kansas City, Topeka, and Western road, which has proved the farsightedness of the company and a very profitable investment. The mileage of the road has been increased yearly by numerous branches and projections of the main line, until now it reaches a total of nearly 1,200 miles. The company has just completed a bargain with St. Louis and San Francisco Railroad Company, which will be of immense advantage to the Atchison, making it not only in name but in fact the "Boston Pacific." The two named companies jointly will build a road along the 35th parallel from the Rio Grande to the Pacific coast, under the charter and name of the Atlantic and Pacific Railroad. The road when done must be the favorite route of travel across the continent, avoiding, as it does, the extremes of heat and cold. The vast and wealthy mineral region which it will open up can but make an immense local traffic, and one can hardly estimate the worth of such an extension to the Atchison, Topeka, and Santa Fe road.

It is but just that the men who have fostered this enterprise in its infancy and weakness should have honorable mention in this sketch. They deserve high praise for fidelity to their trust. Many new friends of "Atchison" have appeared since prosperity smiled upon her. There are but few left on its management who have been with the road from the time when it first became a Boston concern. These men know what struggles the company have had to keep its head above water, and have given a large part of their strength for years to the preservation of the life and to promoting the strength of the "Atchison." These men cannot be praised too highly. If honorable and honest success has ever been achieved in railroad management "Atchison" has achieved it. The name is a synonym for honor, honesty, and true economy. We might add also equality, for it has been a rule of the company that all should be treated alike. The holder of one share has had his rights respected, and the holder of thousands of shares has had no more. The names of Ginery Twichell, Thomas Nickerson, Isaac T. Burr, F. H. Peabody, Joseph Nickerson, Alden Speare, B. P. Cheney, George B. Wilbur, and Charles W. Pearce, who were on the board of directors from 1874 to 1878, were a tower of strength and a guaranty of good management. Several changes have occurred in the board since the election of '78, but the strength of the body has not been impaired. Great changes are hinted at to occur in the near future. What they may be the writer knows not, but he knows that if a new management comes into possession of the company's affairs it will find those affairs in splendid condition.

To single out for special mention any one of the above-named gentlemen, who have worked so long together in this enterprise, may seem to be unnecessary, but any one who knows the inside of "Atchison" matters here in Boston must know that to Thomas Nickerson, the president of the company, more than to any other one person, the success of the enterprise is due. Probably no one will be more willing to assent to this statement than his associates themselves. We have heard many of them say the same thing. Mr. Nickerson has from the first inspired confidence in the public. He has always been noted for his fidelity to trust and his untiring devotion to the cause or the work which he undertakes. When he went into the railroad he threw his whole soul into it, and worked for his company as if it and his own life depended upon his efforts. He is a born leader, and one who has followers because they see he can lead them to success. He never secured the strong support which his company has had here in Boston by rose-colored representations; but capital has waited his call because the men of capital were sure that what he enlisted in himself it would be safe for them to invest in, under his care and management. Their confidence has not been misplaced.

It is rumored that he will resign the presidency of the "Atchison" soon, to enter upon the duties of president of the Atlantic and Pacific road. If he goes out of Atchison now, he goes out with honor enough to satisfy man's ambition. He found the company struggling for existence, and its securities hardly able to find buyers at any price; he leaves it with all its securities above par, and its stock selling for almost $150 per share, with a large surplus of earnings over dividends in the treasury. As the Union Pacific road itself is a monument to the energy and tenacity of Oakes Ames, the Atchison, Topeka, and Santa Fe Railroad is a monument to the industry and integrity of Thomas Nickerson.—*Boston Advertiser.*

THE GUNS OF THE FUTURE.

A DISCUSSION took place at the Royal Artillery Institution, Woolwich, on February 3, on the gunnery question, and was of special interest and importance at the present time. It arose from a lecture dealing with the recent experiments at Meppen, the lecturer being Captain Orde Browne, late of the Royal Artillery, who contended that Krupp's 71-ton gun was a much better weapon than the British 80-ton gun, as it fired a heavier projectile with a higher velocity, producing 1½ inch more penetration, with less pressure upon the bore, the only reason being that it is a better proportioned gun, its main advantage being its greater length. He argued that breech-loading had become imperative, because the labor and inconvenience of muzzle-loading increase with the length of the gun, and ultimately became almost impossible.

Lieutenant-General Sir John M. Adye, K.C.B., late Director of Artillery, and at present Governor of the Royal Military Academy, Woolwich, remarked that the 80-ton gun was designed six years ago, and it was only to be expected that the progress of science would produce better results in ordnance of later date, and some of our own muzzle-loaders of smaller caliber had already beaten the corresponding breech-loaders of Germany. His own opinion, which was supported by that of Captain Andrew Noble, of Sir William Armstrong's firm, was that there was no difficulty in making guns, whether breech-loaders or muzzle-loaders, which, being of the same caliber, shall produce identical results in range, accuracy, velocity, and power. Other considerations, though important, were not vital. Which, for instance, is the more convenient, the more rapid, the simplest, the cheapest, and the safest? He doubted the assertion of Captain Orde Browne, that great length was fatal to muzzle-loading, for the 38-ton gun, which was 19 feet long, was tried five years ago in a contracted casemate at Shoeburyness, being loaded by hand, and fired for two days at the rate of one round in two minutes. He doubted whether so prolonged and crucial a test had been applied to any breech-loader of the same size. He feared that breech-loaders in turrets, having to be frequently opened, might half suffocate the crew, and that the necessity of using great care in opening and closing the breech in a dark and confined space might cause confusion, delay, and accident. He instanced the bursting of a large Krupp gun on board a German training ship, killing and wounding all the gunners save one, and said this was by no means a solitary case. The German 9-pounder used in the war with France in 1870–1 fired only the small charge of 1 lb. 1 oz. of powder, and yet large numbers of these failed in service, the German official reports showing that 210 became disabled, chiefly from the weak breech-mechanism. These siege guns were also so uncertain that, out of seventy of them before Paris, thirty-six became unserviceable in fifteen days. Colonel Maitland, R.A., reported that two Krupp field guns out of five in one battery became disabled by the enemy's fire in the Russo-Turkish war. Herr Krupp had stated in 1878 that the whole of the German breech-loading siege guns and field artillery had been remodeled, which was a confession of weakness, and the test of war had not yet been applied to establish the improvement. In concluding a lengthy address, Sir John Adye admitted the desirability of extended experiments, and stated that the breech-loaders now in course of manufacture at the Royal Gun Factories, Woolwich, would afford the means of ascertaining much that was at present doubtful on the subject.

General Gordon, C.B., R.A., expressed a conviction that breech-loading ordnance was a necessity forced upon the nation, as muzzle loaders could not be further lengthened and had consequently reached their extreme power. Breech-loading enabled Krupp to make his guns twenty-two times as long as the bore's diameter, while England's 38-ton gun was only 18 diameters, and the 80-ton gun was of about the same proportion. The power of the Krupp gun was undoubtedly greater than that of the 80-ton gun at present; but if they could put on a few more feet at the muzzle, he was satisfied that the comparison would be reversed. But, in order to load a larger gun, they must have a breech arrangement, and it need not be a weak one. The gun which burst on board the German training ship was an old one, and it did not give way at the breech. There had been good reasons for hesitating before making such a costly alteration in the national armament, but the change was inevitable, and could not come too soon.

Admiral Boys, who was asked to state the views of the Royal Navy on the question, said there was a general desire for a full and careful series of experiments, and the Admiralty and War Office were fully in accord in desiring the most complete efficiency. No one would prefer breech-loading guns to muzzle-loading guns without good reasons, and the thorough change of stores which would follow the adoption of a new system was strongly against it. He cited some facts to show that the present guns were accurate and sufficiently rapid in action, and showed that the gunners were better protected now than they would be if they had breech-loaders on board ship; but, nevertheless, he admitted that recent researches favored a change of system. The improvements in gunpowder and the conditions of firing it pointed to the increased length of the gun as a necessity, and a ship could not carry long guns unless they were breech-loaders.

Admiral Hamilton, Surveyor of Naval Ordnance, supported the remarks of Admiral Boys.

Major Sladen, R.A., Professor of Artillery at the Royal Military Academy, Woolwich, thought that breech-loading guns would always be more dangerous than muzzle-loaders, but that they would be more accurate, as better adapted for centering the shot: and, as they were in the direction of progress, the risk would probably have to be accepted.

Major Stoney, R.A., Instructor at the Royal Artillery Institution, deprecated a hasty acceptance of the German model, and especially objected to the introduction at present of steel guns.

General W. J Smythe, R.A., F R.S., who presided, expressed the thanks of the meeting to Captain Orde Browne for his paper, which had led to so interesting a discussion. The question was a very important one, and it ought to be thoroughly investigated, in order to satisfy public opinion, and bring about the result every one desired in promoting the thorough efficiency of the national armaments.

THE FRACTURE OF CAST IRON.

AT a recent meeting of the Civil and Mechanical Engineers' Society, a paper by Mr. James Love, F R.A.S., F.G.S., on the above subject, was read. The author described experiments on the peculiar form of fracture of cast iron, and showed its similarity to the fracture of other materials, such as glass and sealing wax. He further showed by his experiments that these lines were nearly at right angles to the lines of equal stress, demonstrated by the Astronomer-Royal some years back. Arguing from this standpoint, Mr Love proved the viscosity of many materials, and its connection with heat and regelation, which he has found in many substances, including iron. He also showed that the ordinary process of welding iron was due to regelation, and that cast iron could not be welded in consequence of the presence of carbon in the form of graphite.

APPARATUS FOR HOT PRESSING.

By means of improved machinery arranged by Mr W. Cochrane, the process of hot-pressing woven fabrics is conducted in a continuous and rapid manner. For this purpose a series of hollow iron rollers are employed, these being arranged in a horizontal row, with their end journals placed in horizontal slots in two parallel side frames. The rollers are compressed together horizontally by hydraulic cylinders acting against the bearings of the rollers at one end of the machine, and connected by tension rods to cross heads acting against the bearings of the roller at the other end of the machine. The rollers are driven alternate directions by means of worm wheels on their journals. Some of the rollers at or near the entering end of the machine are heated by means of steam, or hot water, or by burning gas; whilst the rollers at and near the delivery end are cooled by means of cold water. Two endless cloths (each of which may be single or compound) are combined with the rollers, and the fabric to be hot pressed is led in between these two endless cloths, and *e* is carried with them in a serpentine course round the rollers from the entering to the delivering end of the machine.

The improved hot-pressing machine is illustrated in plan by Fig. 1, and in longitudinal vertical section by Fig. 2.

The framing consists of two parallel compound side frames, supported on cast iron stools at the ends; and each

side frame consists of a pair of cast iron girders, 2 and 3, placed one above the other, so as to leave a longitudinal slot or space between them. Combined with these girders are upper and lower tension rods, 4 and 5, of wrought iron or steel, and vertical cross heads, 6 and 7, also of wrought iron or steel, at the ends. The tension rods, 4 and 5, pass through the ends of the girders, 2 and 3, and through the cross heads, 6 and 7, and nuts screwed on their projecting ends bind the whole together.

Between the side frames there is a row of hollow transverse horizontal rollers, 8, 9, 10, 11, 12, the end journals of which project into and are guided by the slots in the side frames. Bearing blocks, 13, 14, are fitted to the journals of the end rollers, 8, 12, and whilst at one end the bearing blocks, 13, have their outer vertical faces bearing against blocks, 15 (which are between the ends of the girders, 2, 3), and through them against the cross heads, 6, at that end; the bearing blocks, 14, at the other end are pressed by the rams, 16, of hydraulic cylinders, 17, fixed to the other cross heads, 7.

ceeds through the machine between the cloths, being finally delivered from between them at the other end of the machine. The fabric is thus simultaneously subjected to heat and pressure; and the effect is rendered permanent by the fabric being cooled whilst still under pressure, the entire operation being effected in a continuous and rapid manner. —*Universal Engineer.*

THE POROSITY OF BUILDING MATERIALS.*

LANGE gives, by calculation from experiments, the pressure on the outer walls of a house 20 meters high, at a barometric pressure of 718 millimeters, the inside temperature being 27·3° C. and the outside temperature 0° C., 1·114 *kilogrammes per square meter of the exposed surface.* The amount of ventilation resulting from this pressure depends upon the nature of the building materials used, and may be easily calculated when the latter is known.

As for the second consideration, the diffusive power of gases, its influence upon the ventilation of a house through the outer walls is, owing to the small difference in mechanical mixtures of the air within and without, and to the consequent diminutive pressure against the walls either way, *too small to be appreciable*, and it may therefore be ignored.

By far the most important agent in natural ventilation is the wind.

The following table, calculated from Peclet and Smeaton,† shows the pressure of a direct wind per square meter:

coming from the former is so uncertain in its amount and so disagreeable and dangerous in its character that every precaution should be taken to reduce it to a minimum. By the use of good cements, packing, and rubber mouldings, it may be reduced to so minute an amount as to be practically inappreciable.

Porous building materials have the advantage of greater capacity for warmth. The conductibility decreases as the porosity increases, and what air passes through the walls of a building is warmed in its passage. But inasmuch as the loss of heat in radiation from the outer walls into space is the same for an equal difference of temperature between these walls and the objects receiving the rays, such a transmission of cold air through them must cool them to an extent nearly corresponding to its amount, and deprive them largely of their healthful action in radiating heat upon the bodies of the occupants. The greatest desideratum in heating is to have the walls and floor of a room as warm as possible, leaving the breathing air comparatively cool; and anything tending to destroy this effect should be avoided as far as possible.

Experiments have been made by Pettenkofer, Schultze, Märcker, Lange, and others on various buildings, to determine the quantity of air passing through the walls in a given time under a given pressure. Pettenkofer found that the amount of air which passed through the walls of his study per hour was 0·245 cubic meter per square meter of wall surface for a difference of 1° C. between the external and the internal temperature. But these experiments give no reliable or accurate data for practice. The only way to obtain correct results is to make the tests on a simple scale with small pieces of material under a known pressure.

The principal building materials used in different countries differ greatly in their permeability to air. In Germany they appear to be in general more porous than in this country, so that, perhaps, for this reason the need of artificial ventilation is less directly felt with the Germans than with us.

Of all building materials none differs more widely in the matter of porosity than baked clay or terra cotta, the material most extensively used. In the form of certain kinds of fire-brick its porosity resembles almost that of a sponge, while in the form of vitrified or glazed tile it is absolutely nonporous. A piece of semi-vitrified terra cotta, used in a furnace constructed by the writer, was tested by him, and found to permit only 9 cubic centimeters of air to pass through per hour under a pressure of 10 centimeters of a water column, which is equivalent to a pressure of 10 grammes per square centimeter. The piece was 30 millimeters thick, and presented a surface of 35 square centimeters to the pressure. For a

Velocity in Meters per Second.	Velocity in Kilometers per Hour.	Remarks.	Pressure in Kilogrammes per Square Meter.
0·5	1·8	Breeze hardly felt.	0·03
1	3·6	Breeze sensible.	0·2
2	7·2	Moderate or pleasant wind.	0·5
5·5	19·8	Quite strong wind.	4·5
10	36	High wind.	20
20	72	Very high wind.	56
22·5	81	Storm.	78
27	97·2	Severe storm.	105
36	129·6	Hurricane.	186
45	162	Hurricane which uproots trees and overthrows houses.	290

For an average velocity of the wind of 27 kilometers an hour we should have a pressure of one-half kilogramme per square meter. A wind stronger than 36 kilometers an hour would be exceptional, and is not to be reckoned upon. This would give us, according to the table, 22 kilogrammes per square meter. But in all cases it is necessary for the wind to strike the surface at right angles in order to exert upon it a pressure corresponding to that shown in the table. In consideration of the great variety of force and direction of the wind, it cannot be counted upon as a reliable source of ventilation, our table showing a pressure varying all the way from 0·03 kilogramme to 290 kilogrammes per square meter.

It remains now to ascertain the effect of this pressure in transmitting air through the walls of our buildings. The air may be forced through the wall in two ways, namely, either through the accidental cracks at joints, or through the pores of the materials themselves.

No arguments are needed to show that the ventilation

* From the *American Architect and Building News.*

† *Fortschritte der Physik.*

FIG. 1.

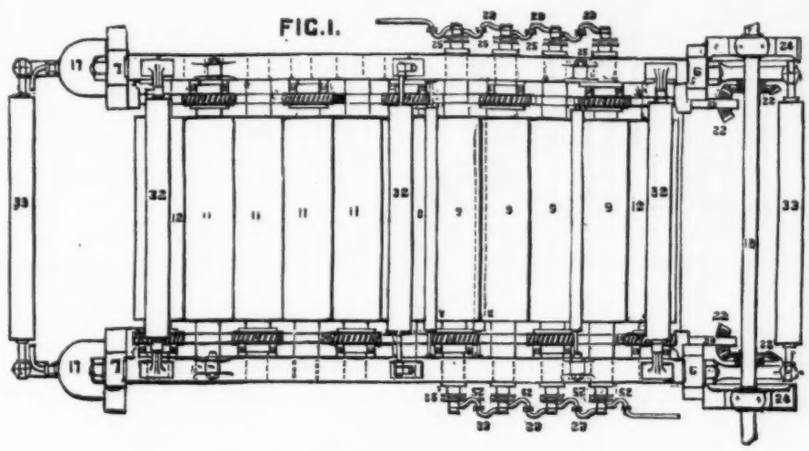
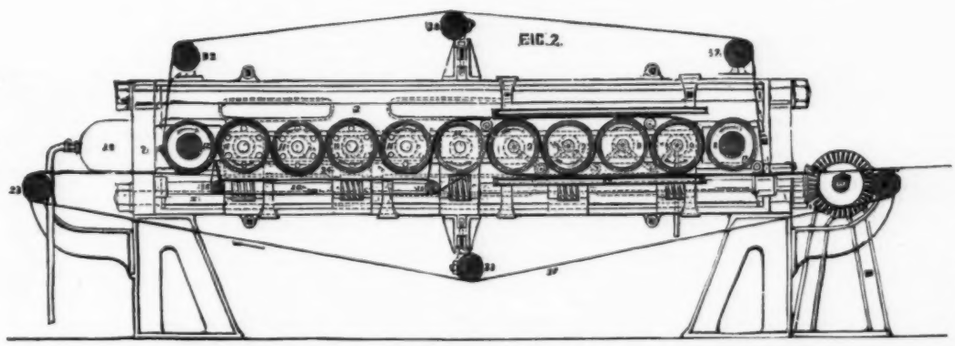


FIG. 2.



IMPROVED APPARATUS FOR HOT PRESSING.

The rollers, 8 to 12, are made to rotate in alternate directions by means of worm wheels, 18, fixed on their journals; these worm wheels, 18, being at opposite ends of the rollers alternately, and being in gear with worms, 19, on two horizontal shafts, 20, placed one at each side of the machine. Bevel wheels, 21, on the shafts, 20, are in gear with bevel wheels, 22, on a transverse horizontal driving shaft, 23, which is carried in pedestal bearings, 24, at one end of the machine.

The entering end of the machine is toward the right hand in the figures, and four of the rollers, marked 9, near that end, are arranged for being heated internally by steam or hot water; being fitted with stuffing boxes, 25, at their journal ends, and with pipes, 26, which are jointed to accommodate any slight movements of the rollers.

In order to apply additional heat, two flat steam chests, 27, 28, are fitted one above and the other below the steam heated rollers, 9, being held by brackets attached to the side frames.

The two endless cloths, 29, 30, proceed together under a guide roller, 31, at the entering end, and horizontally over the lower steam chest, 28, to the furthest steam heated roller, 9, returning thence alternately over and under the rollers, 9, to the entering end. The cloths then proceed horizontally under the upper steam chest, 17, to the middle roller, 10, and then continue passing alternately under and over the cooling rollers, 11, and finally under the end roller, 12. The cloths then separate, the upper one, 29, passing above the machine over guide rollers, 32, to the entering end, and the under cloth, 30, returning under guide rollers, 33, at the ends, and beneath the machine, also to the entering end.

One, 32, 33, of each set of guide rollers is carried in bearings which are adjustable by screws, by means of which the endless cloths can be kept distended with sufficient tightness.

The cooling rollers, 11, are partly immersed in a trough or shallow tank, 34, containing cold water, which is continually renewed, and which has access to the interiors of the rollers, 11, by holes at their ends.

The endless cloths, 29, 30, are made of or have combined with them any suitable material that is impervious to moisture; and to prevent the water in the trough from getting between them at their edges, endless cords or bands, 35, are passed round guide rollers, 36, under the trough, round the middle roller, 10, and round the cooling rollers, 11. These cords or bands, 35, are kept tight by a suitable adjustment of one of the guide rollers, and they nip the endless cloths, 29, 30, near their edges (and beyond the edges of the fabric that is between them undergoing the hot pressing operation) at the part of their course where they dip into the trough, 34.

The fabric to be hot pressed is led in between the endless cloths, 29, 30, at the entering end of the machine, and pro-

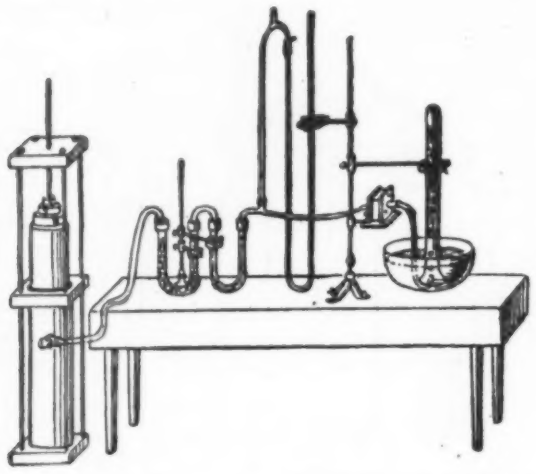
THE POROSITY OF BUILDING MATERIALS.

surface of 1 square meter the amount of air forced through would have been 2·6 liters per hour, under the same pressure of 10 grammes per square centimeter.

Other pieces, in the form of brick, were tested by Dr. Henry P. Bowditch, with the following results:

Four Taunton bricks allowed the air to pass at the rate of about 62, 160, 106, and 795 liters respectively, per hour, for the same surface (1 square meter), same thickness (3 centimeters), and same pressure (10 grammes per square centimeter). North Bridgewater bricks gave 66 and 132 liters; a New York brick, 330 liters; New Jersey bricks 24 and 53 liters; a Philadelphia face brick, 891 liters; a hard Eastern brick, 165 liters; and a Danvers face brick, 231 liters. Ohio sandstone gave 990 liters.

The apparatus used for our tests is here represented. Air



was compressed in a gas-holder, shown at the left of the table, and conducted by a rubber tube to two bent glass tubes, containing, the one chloride of calcium and the other sulphuric acid, in passing through which it was thoroughly dried. The pressure was measured by a water manometer, and the piece of material to be tested was held between two cups of iron securely connected with the rubber tube in such a way that the compressed air could enter freely one exposed side of the sample and escape at the opposite side. The four remaining sides were covered with an air-proof cement, composed of wax and rosin, to prevent the escape of air at any other points than that covered by the cup and tube opposite the one delivering the fresh air, and the whole was kept under water during the test, so that any escape of air might at once be detected by bubbles. The air thus pressed through the material to be tested was finally delivered into a graduated glass vessel inverted over a basin of water and measured. The same apparatus was used for testing the soapstone before referred to.

The apparatus used by Lange in making his more extended tests in Germany was similar to that above described, except that he measured the volume of air before instead of after passing it through the material to be tested. This method was less exact because some of the air measured might not be actually transmitted through the material, owing to leakage.

The observations of Schürmann* and Lange show that the amount of air passing through porous materials of homogeneous structure under constant pressure is inversely proportional to the thickness of the pieces tested.

Lange gives the following table showing the permeability of various materials under a constant pressure of 10 grammes per square centimeter, and the amount of air in liters or cubic decimeters passing through them per hour, per square meter of surface, the pieces tested being 30 millimeters thick.

According to Lange and Märcker, burning increases the porosity of brick up to the point of vitrification, when it becomes non-porous. The different kinds of bricks vary greatly in porosity. Mortar is exceedingly porous, but after remaining some time immersed in water it becomes less so. We see by the table that Portland cement transmits 492 liters per square meter, under the slight pressure of 10 grammes to the square centimeter, or about the hundredth part of one atmospheric pressure. It cannot, therefore, as in the form of concrete for basement cellars, be considered by any means as air or damp proof.

Materials Tested.	Amount transmitted in Liters.	Its Permeability is represented by
Green sandstone (Bavarian)	468	0·130
" " (Swiss)	426	0·118
Limestone (calcareous tufa)	28,728	7·980
ARTIFICIAL STONES.		
Brick, sandal brick of Opnabruck	1,398	0·383
" lightly burnt hand-made (Munich)	312	0·087
" hard burnt " "	732	0·203
" machine-made "	474	0·132
CEMENTS.		
Mortar	3,264	0·907
Beton	930	0·258
Portland cement	492	0·137
Plaster (gyps.) cast	146	0·041
WOODS.		
Oak	24	0·007
Pine	3,636	1·010

The different woods vary greatly, pine being more porous even than mortar, and oak less porous than the densest brick. Tufaceous limestone was found to be the most porous substance tested.

The different kinds of bricks and sandstones vary greatly. Ten different kinds of sandstone given by Lange varied between 0·3661 and 0·009 cubic meter of air transmitted under the same pressure in the same time, the French sandstone tested transmitting forty times as much air as the German (Sollingsandstein), which was the least porous.

Lange found that a coat of water-glass (silicate of soda or potash) diminished the porosity, and the more so the longer it stood, until after a certain time it rendered it entirely non-porous. Oil paint acted in the same way as long as it was new. Water color with glue size (Leim farbe) diminished greatly the permeability more than half, and the more the stronger the sizing. Lime water color (Kalk farbe) diminished it the least. Papering diminished the porosity more or less according to the nature of the paper and the thickness of the paste used in hanging it. The diminution of the permeability varied for different tests between 18 and 75 per cent.

Dampness, due to rain on brickwork, etc., diminished the permeability according to the degree of the moistening, in some cases rendering a porous material absolutely non-porous, as in the case of Beton and Portland cement.

Knowing, then, the permeability of our building materials and the pressure of the wind, it is easy to calculate the natural ventilation in any given case. Suppose, for instance, we have a room 6 meters square and 4 meters high, with one exposed side, and that the exposed side contains a window 1 meter wide and 2 meters high. The walls are 40 centimeters thick, 30 of which are brick, 4 air-space, 3 lath, and 3 plaster, and present a surface of 24 square meters to the outer air. Take out 2 meters for glass surface, because glass is non-permeable, and we have 22 square meters of brickwork exposed. We have found that 1 square meter of hard Eastern brick 3 centimeters thick will admit 165 liters of air under a pressure of 10 grammes per square centimeter. We have, by our table, for plaster 146 and for laths 3,636. But supposing their permeability and that of the mortar to be the same with the brick, we have over 40 centimeters thickness of wall, $\frac{165 \times 3 \times 22}{40} = 250$ liters of air transmitted under the pressure of 10 grammes per square centimeter, or 100 kilogrammes per square meter.

This pressure is, by the table, equivalent to that of a severe storm bearing directly upon the house.

For a moderate wind the pressure would be about 250 times less, and we should have a ventilation of only 1 liter per hour. For a Philadelphia face-brick wall we should have about 5 liters per hour, up to 500 liters, or half a cubic meter, in case of a severe storm. For a gentle breeze, direct, it would be about 2 liters per hour, and at right angles with the wall, say, 1 liter again per hour. If the wall were papered on the inside or painted in distemper, these figures would be reduced, say, one-half, and if oil paint were used the ventilation would be reduced to nothing.

Where the walls are built of the limestone given in Lange's table as transmitting 28,728 liters per hour, the ventilation in a high wind would amount to $\frac{28,728 \times 3 \times 22}{40} = 47,388$ liters = 47·4 cubic meters per hour, or 0·8 cubic meter per minute, an amount quite sufficient for a single occupant. Thus we see that the ventilation, left to the natural permeability of the material, would vary with every material and with every change of the wind, being greatest when the wind was highest and the exterior air was coldest, or, in other words, when least desired. It is, therefore, in the highest degree unreliable. Such a form of air supply is objectionable, too, in most cases, on account of its cooling action upon the surrounding walls. We have seen that (calculating from Lange's figures) a building material may admit air enough to supply one person for every 22 square meters of wall surface exposed directly to the wind.

The matter assumes, then, considerable importance, and demands of the heating and ventilating engineer careful study. Indeed, it is easy to obtain bricks and stones so porous that a candle may be blown out by a slight effort of the breath through pieces many centimeters in thickness. The experiment may easily be performed by any one by attaching rubber tubes to opposite sides of the sample to be tested and covering the remaining sides with wax in the manner described.

While, therefore, it may for many reasons be desirable to employ porous materials for building, these materials should be carefully coated with non-permeable substances, either outside or inside, or both, and every precaution possible should be taken to prevent the entrance through them of the outer air, though I am aware that this conclusion is exactly the reverse of that held by Lange and others.

If there were cases where no other sufficient fresh air supply *could* be obtained than through the pores of the building materials, natural ventilation might be recommended. As it is, there are, unfortunately, many buildings in which no other sufficient supply *is* provided, and natural ventilation then becomes, in spite of us, a great good; but as our question here is with well and not ill ventilated buildings, accuracy and success in our arrangements require us to know its greatest extent and provide against it.

* "Jahresbericht der chem. Centralstelle für öffentliche Gesundheitspflege in Dresden."

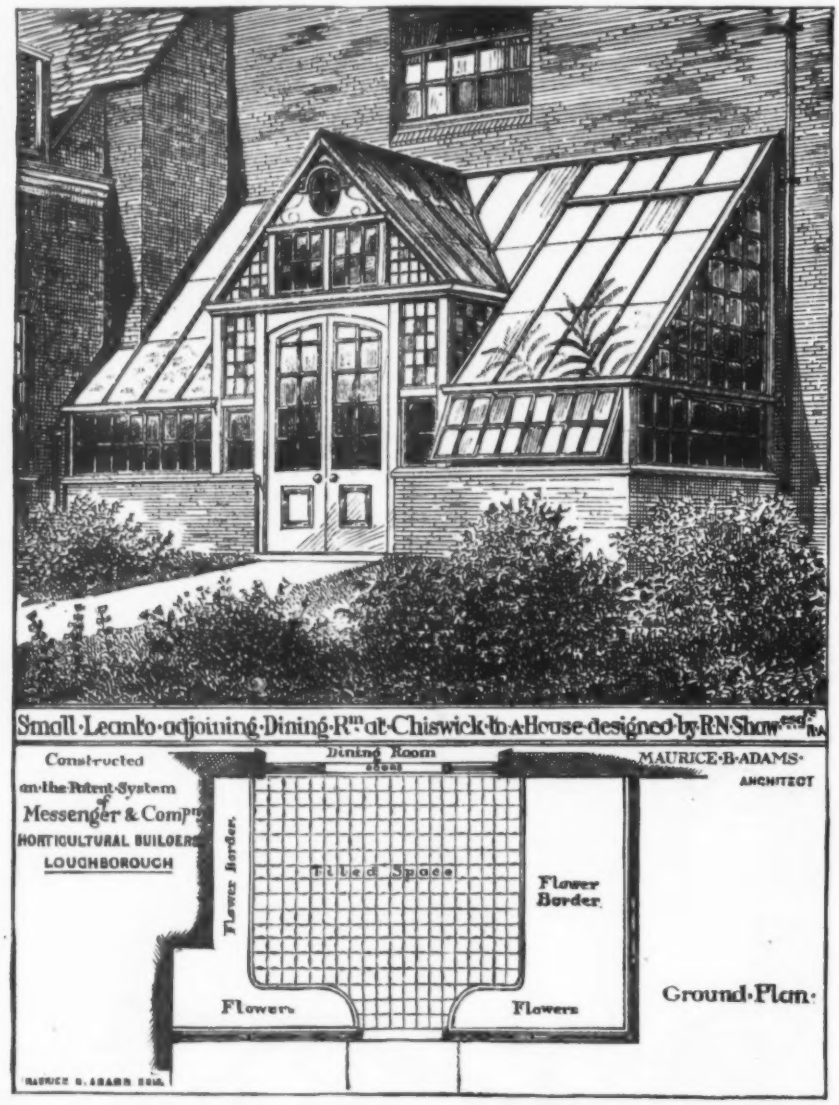
MOSAIÇ PAVEMENT IN CORK CATHEDRAL.

THE marble mosaic pavements in the apse and chancel of Cork Cathedral, the work of Mr. Burges, cover a surface of about 100 yards, and are of the most elaborate kind of work, known as opus vermiculatum, the tesseræ varying in size from half to one-eighth of an inch on the face. The subjects depicted are illustrative of Scripture allegory and parables. For the principal design in the apse Mr. Burges has taken as his text Matthew xiii. 47: "The kingdom of heaven is like unto a net that was cast into the sea, and gathered of every kind." The surface of the apse pavement is divided into hexagonal panels in three rows, with diamond-shaped panels between, surrounded by bands of red and green colors formed of several lines of graduated tones, joining at the sides of the hexagonal and points of the diamond panels with circles, the whole artfully arranged by the interlacing of the shaded bands, to form, as it were, the net (the panels being the meshes), which, fastened by cords to corks within the pillars, floats upon a grayish-white ground, while within the corks the water rolls up in curling waves. The hexagonal panels, 2 ft. 11 in. at longest point, contain figure subjects portraying the various conditions and callings of men. In the front row is the King, a well-drawn figure, with crown of gold, and wearing a red robe and yellow tunic; from his shoulders descends a green mantle with ermine collar, and in his hand are the insignia of regal state. To the left is the Doctor, in a gray gown lined with yellow; the expression of this figure is very fine, the face lighted with animation as he reads the book he holds in his hands before him. The third figure in first row is Artifex—the particular workman a carpenter; the action and position are well rendered. In the second row above Artifex is Servus, in attitude of supplication, hands clasped and chains depending from his wrists. Then comes Agricola, in the act of reaping, the left hand gathering the corn he has just cut, with the sickle in his right. Next is Venator, in red dress; in the left hand he carries a bow, in the right an arrow, while over his shoulder is slung his quiver; the figure full of life, as he runs in search of game. In a line with these are Piscator, in simple fisher's garb of gray color, holding up a net containing two fishes; and Rusticus, with his left hand on the stem of a tree he is about to fell with the ax he holds in the right. The last figure of this row is Infans, holding in his hand a child's toy. The graceful simplicity of this figure is very pleasing. In the third row, at one side of the altar, is Mercator, a well-studied figure, seated at a desk, writing; and at the other side is a warrior in armor, in the act of drawing his sword from its scabbard. In the diamond-shaped panels are representations of various kinds of aquatic life. Beyond the communion rail the subjects illustrated are—in the center the grain of mustard seed, on one side the sower, on the other the Good Shepherd, the three united into one design by an elaborate fret border. The chancel pavement is in the same style, but of a simpler treatment. These pavements have a claim upon our attention, not only for their highly artistic qualities, but as showing the progress of the revival of one great branch of the decorative arts, for many generations neglected in this country. A history of the revival of the art of mosaic is out of place here; it will be found in the various works and lectures of the late eminent pioneers, Sir Digby Wyatt, Owen Jones, and others. But in the material part of this mosaic work we may note a very important fact, viz., that whereas in many old mosaic pavements we find the artist and mosaicist, when at a loss for certain colors, employing enamels and terra-cotta, in the Cork pavement only nature-colored materials, that is marbles and limestones, collected from various foreign and home quarries, have been used; but with these Messrs. Burke have produced a wonderfully varied pallet of different tones and colors—yellows running through many shades, from brilliant Sienna marble to the more subdued tones of the French limestones; greens, from the vivid green of Connemara to the somber green of the Alps; reds, from the pale pink of Portugal to the dark-colored Rosso Antico of Greece and the purple tones of Rhondona; whites, from the different Carrara marbles to the cream limestones of France and England; neutral colors and tones from the limestones of Burgundy and Provence, and the lithographic stones of Germany. In producing this varied pallet of colored tesseræ, it will be easily understood that a great deal of marble is cut to waste to obtain the tone required; but thus procured many are almost equal in richness of color and texture to the more valuable hard stones employed by jewelers. In the pavements above described the figure subjects demanded a very extensive range of colors, all of them running through three or four tones. The green, red, and yellow bands of the interlacing guilloche border; the gray, white, and green of the wave fret; the yellow and brown of the floats; the reds, purples, and delicate coloring of the branches and birds in the "grain of mustard seed" subject required not only a great amount of patience, but of thought and research in collecting together the forty or fifty different kinds of marbles and limestones necessary for the purpose.—*Building News.*

MOSAIC PAVEMENT OF CHANCEL, CORK CATHEDRAL.

SMALL CONSERVATORIES.

THE small lean-to, from Chiswick, may be taken as an example of the sort of glasshouse or conservatory often required at the rear of suburban dwellings, where limited gardens are the rule, and where, for more reasons than that of expense, a simple treatment is necessary. The house to which the illustrated lean-to adjoins, is one of a semi-detached pair of unpretending red-brick villas in the Queen Anne style, by Mr. Norman Shaw, R.A., letting at £60 per annum each, and this fact is named in order that the conditions which governed the designer of this conservatory in preparing his plan may be noted. Limited height in the front was ruled by the necessity of not obstructing more light than possible from the next house, and restricted depth was determined by the pantry window, which shows on the view, while the lighting of the dining-room made it, above all things, necessary to keep the lean-to framing as unobstructive as possible. The building is about 14 ft. by 9 ft. on plan. The necessity of external doors corresponding somewhat in size to those in the dining-room suggested the gable, which is made somewhat large in outline, so as to bear comparison with the rather big dormer which connects the nursery on the first floor with the balcony just seen on the left-hand of the sketch. The cornice inside corresponds with that of the exterior, and the upper part of the gable contains a carved oval light, with moulded hood on both sides. The two fan-lights under this are made to open, and so are the front-lights and ventilator in roof. The quarry glazing is by Shrigley & Hunt, of Lancaster, in greens and blues. The woodwork inside is finished in pale pea-green, and outside in dead white. The heating is by a gas-stove, reached from the outside, and three rows of hot-water pipes extend round two sides of the building, the floor of which is paved with 4 in. red tiles having natural flower borders for palms, camellias, etc., on either side, and shelves range round at a higher level. The building was executed with purpose-made mouldings and fittings, etc., by Messrs. Messenger & Co., of Loughborough.—*Building News.*

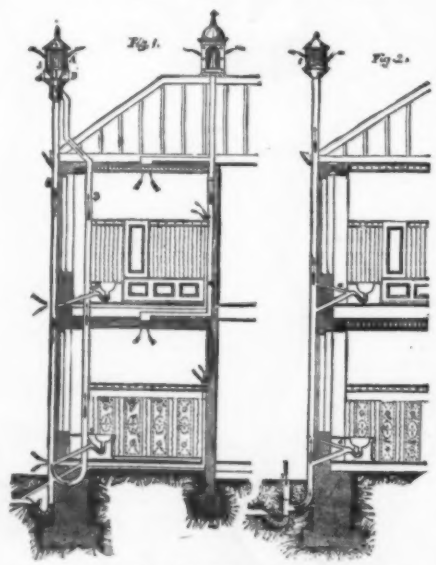

Small Lean-to adjoining Dining Rm at Chiswick to a House designed by R.N. Shaw esq.r R.A
Constructed on the Patent System of Messenger & Comp.y HORTICULTURAL BUILDERS LOUGHBOROUGH
Dining Room
MAURICE B. ADAMS ARCHITECT
Flower Border
Tiled Space
Flower Border
Flowers
Flowers
Ground Plan

DESIGN FOR A SMALL CONSERVATORY.

IMPROVED SOIL PIPE VENTILATOR.

MESSRS. ROBERT BOYLE & SONS, of Glasgow and London, have produced the arrangement for the ventilation of soil pipes which we illustrate in the accompanying engraving, Fig. 1, and which appears to us well worthy of attention. The arrangement consists of an "air pump" or extracting ventilator, A, connected with the up-cast ventilating pipe, 2, while the down-cast ventilator, B, forming the lower portion communicates with the soil pipe, 3. From the arrangement of the plates or division, 4, the down-cast ventilator presents an open mouth (on the principle of the wind sail) to the wind from whatever quarter it may blow, the air being thus forced down the soil pipe, and up the ventilating pipe as indicated by the arrows. By this combination of up-cast and down-cast ventilators a thorough circulation of air through the soil pipe is insured, the fact of the inlet or down-cast ventilator being placed at a high elevation greatly assisting in securing its exposure to the currents of air on which its action depends.

Both pipes, 2 and 3, may be placed inside the house or outside, as preferred, or the soil pipe may be fixed inside to protect it from frost in the winter time. There would not be the slightest danger, however, in having it in the house with the double-action ventilator applied. In our illustration it is shown by Messrs. Boyle placed outside, so that the up-cast pipe may have the benefit of the heat in the house which tends to rarefy the column of air in the up-cast pipe. These conditions alone assist greatly to maintain a continuous through current independent of the force of the wind. At 5, 5, 5, are ½-in. pipes to ventilate the discharge pipes connected with the water-closets, and prevent the traps being unsiphoned by the passage of matter down the soil pipe, while 6 is the drain trap, and 7 a 2-in. ventilating pipe connecting the drain with up-cast pipe where no provision is made for ventilating the drains separately. Altogether this arrangement of Messrs. Boyle & Sons is a very promising one. Mr. R. P. Beattie, plumber and sanitary engineer, Edinburgh and London, has used these double pipes very extensively, and we understand they have been found to answer exceedingly well. He uses the "air pump" ventilator for creating an upward current, but the double-action ventilator will now, of course, answer his purpose much better.



JAPANNED SOIL PIPE VENTILATOR.

Fig. 1 of our engraving also shows how Messrs. Boyle & Sons ventilate the water-closet by means of one of their "air pump" ventilators placed on the roof with a main pipe led down the wall and connected by means of a branch pipe with the center of the ceiling; the fresh air being admitted through a vertical tube placed against the wall close to the door, so that the current of air will always have a direction from the door to the ventilator, which, from obvious reasons, is the proper direction. The vertical tube is connected underneath the floor with an opening through the wall communicating with the external air.

Fig. 2 of our engraving shows a system of soil pipe ventilation which is at present extensively used by sanitary engineers. It consists of a Boyle's "air pump" ventilator, 10 in. in diameter, for creating an up draught and preventing down draught, fixed at the top of the soil pipe as shown, this pipe being prolonged upwards. In this case the fresh air inlet is at 3, there being no separate down-cast pipe as in the arrangement previously described. The drain trap is at 2,

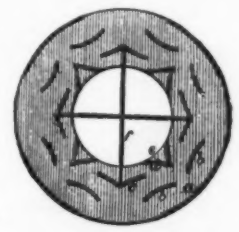


FIG. 3.

while 4, 4, are small pipes ventilating the water-closet traps. One special feature in the arrangements we have been describing is that the "air pump" ventilators used have no moving parts, and hence there is nothing about them to get out of order or make a noise. The horizontal section, Fig. 3, of one of these ventilators will serve to explain their mode of action. From this view it will be seen that the ventilator consists of an outer shell, *a*, having four openings in it. The wind blowing into one of these openings strikes against a curved plate, *c*, and is deflected right and left between the plates, *c* and *b*, on to the plate, *d*. The lateral currents thus produced give rise to induced currents flowing from the spaces, *e*, thus causing the air to be drawn up the shaft to which the ventilator is connected. The escaping currents of air pass off through the openings on the lee side of the outer casing.

MALLEABLE NICKEL AND COBALT.

NICKEL and cobalt, prepared by the electrolytic method, though slightly malleable, become brittle and porous on being melted and cast, resembling in all properties the metals prepared by the ordinary dry method. M. Fleitmann, thinking that the want of tenacity was due to the combination of the metals with carbonic oxide, tried the experiment of adding to the metals, while in a fused state, a small quantity of magnesium. This metal has the property of reducing the oxygen compounds of carbon in virtue of its affinity for the former element. He began by adding ½ of a per cent. of magnesium, and was surprised to find that it effected a great change in the nature of the metals. After this treatment they are capable of being forged and rolled into sheets, either hot or cold, with facility. Cobalt by the latter treatment becomes extremely hard. Cast and cooled in moulds, both metals are similar in all respects to cast steel. When polished they retain their brilliancy in air unimpaired, and contrary to what is usually stated in the text books, cobalt surpasses nickel in luster and whiteness. The metals retain in the form of alloy about one-half the magnesium that has been added. Whether or not the important modifications observed are due to this small proportion of alloy does not seem to be satisfactorily proved.

PHOTOGRAPHY APPLIED TO THE ORNAMENTATION OF GLASSES AND MIRRORS.

EVERY new industrial application of photography possesses great interest for me, says a correspondent of the *Photo News*. The particular one which M. Leclerc exhibited realizes most charming effects in the ornamentation of silvered glass. Caskets and mirrors decorated by this method are really most effective, and the process can evidently be applied to a large variety of articles. A sheet or plate of glass is first silvered on one of its surfaces; this silvered surface is then coated with bitumen, and when the film of that substance is dry, it is exposed to the light behind either a negative or a positive plate, on which the design is rendered either in line or stippling. When the exposure is sufficient, the parts of the bitumen not attacked by the light are dissolved out by spirit of lavender, or by benzine, or by any other solvent of that substance. By this means parts of the silvered surface are left bare. The glass plate is then passed into dilute nitric acid to dissolve the silver, and when this etching (if I may call it so) has been accomplished, the glass will be left quite bare in all the parts that have not been acted on by light. By applying, now, a colored varnish to the back of the plate, the picture is obtained standing out of the silvered ground on the looking glass itself. If the colors, applied to those parts of the glass that have been rendered bare, are skillfully disposed, the effect is elegant and rich in the extreme. This appears to me to be a very perfect method of producing negatives of which the blacks are absolutely opaque, for the light is quite unable to penetrate a film of silver coated with varnish. We have, therefore, a very useful purpose to which M. Leclerc's process can be applied.

LECLERC'S PROCESS FOR SILVERING GLASS.

WHILE I am on this point I will give here a simple method of silvering glass for the benefit of those who desire to attempt M. Leclerc's process. Take first a solution of 2½ grammes of silver nitrate in 32 grammes of distilled water, and precipitate by adding ammonia drop by drop, stirring the whole time with a glass rod, until the brown precipitate produced is partly redissolved. Filter, and add enough distilled water to make 50 grammes of solution. For the reducing solution, dissolve one gramme of the double tartrate of potash and soda in 32 grammes of distilled water. Put it to boil in a glass capsule, and add two drops of a solution of crystallized silver nitrate in water. When it has boiled for five or six minutes, let it cool, filter, and add enough distilled

water to bring it up to 50 grammes. To coat the glass, clean it first with nitric acid, and then place it on supports in a flat dish full of the silvering solution in such a way that its lower surface only touches the liquid. Great care must be taken that no bubbles of air interpose between the surface of the glass and that of the liquid, or they will give rise to bare spots. Sunlight or heat will facilitate the reaction. The liquid will at first blacken during the operation, and will then grow clear again in proportion as the deposition is effected. At the end of from half an hour to an hour the silvering will be complete, though sometimes it takes an hour and a half. When it is quite finished the glass is taken out of the bath and rinsed with distilled water, and so soon as the mirror is dry it is coated at the back with bitumen. If it be intended to keep it as a mirror only, it should be coated with some kind of elastic varnish, not liable to scale off, for if this should happen the mirror would be spoiled.

THE KEEPING OF GELATINE EMULSION.

PIQUÉE, a photographer at Troyes, has observed that gelatine emulsion can be kept under water, and that when it has been kept in this way for a sufficiently long time, its sensitiveness will be considerably increased; this, of course, is owing to the fact that decomposition of organic matter is avoided. His experiments have extended over a period of twenty days. M. Balagny, who is a very skillful operator with gelatine plates, is of the same opinion; he keeps his emulsion in a state of coagulation without being compelled to reduce it to the form of pellicle. This object he attains by placing his stock of emulsion in a cool place, and filling the flasks in which it is kept up to the top, so as to expose only a small surface to the air. A few drops of alcohol poured on the surface of the coagulated emulsion materially assists in preserving it, or a small quantity of solution of ammonia has the same effect.

THE STATUE OF GALVANI AT BOLOGNA.

THE city of Bologna has recently erected a statue in honor of one of its greatest citizens—Galvani. We reproduce herewith the aspect of the marble which is to perpetuate the physiognomy of the illustrious physicist. It represents him at the moment when the muscles of the frog are revealing to him the effects of electricity on the animal organism. This

STATUE OF GALVANI AT BOLOGNA. (From a Photograph.)

remarkable piece of sculpture is from the chisel of M. Adalbert Cincetti, the eminent artist of Rome, Italy.

Luigi Galvani was born at Bologna on the 9th of September, 1737, and died in that city on the 4th of December, 1798. From his very youth he made himself remarked by his ardor in the study of anatomy and physiology. At the age of twenty-five he was made professor of anatomy in the University of Bologna, in consequence of his thesis on the "Bones, their Nature and their Formation." The duties of this place did not prevent him from practicing obstetrics and surgery, and from performing operations in which he showed great ability. It was in 1791 that Galvani was put on the track of the discovery which was to immortalize his name. History gives several different versions of this discovery. It is said that in preparing some frogs to make a *bouillon* for his wife, who was dying of an affection of the breast, he happened to accidentally touch the lumbar nerves of one of the animals with different metals, and noticed that the hind legs thereupon contracted with great force. Again, it is said, that having skinned a frog, taking away its two legs with a part of the spine, he attached the whole to a copper hook which he had hung upon an iron railing near his laboratory. He stood watching to see if the electricity of the atmosphere would produce upon these legs the same effect as the electrical machine. After a time, having observed no sign of electrical influence, he decided to remove the frog's legs, and while doing so he perceived the very muscular contraction which he had been vainly expecting to see produced by atmospheric electricity. He soon discovered the condition of this contraction, which was the contact of the moist limbs of the frog with the iron rail. Having substituted for the copper hook and iron rail a metallic arc composed of pieces of these two metals, he found that he could produce the contraction at will. Galvani first published the results of these experiments in 1791, in his celebrated work, "De Viribus Electricitatis in Motu Musculari Commentarius." According to the theory proposed in this work, the muscles chiefly contain the animal electricity which manifested itself in the above experiments, and which he thought was supplied by the nerves and the blood. When these discoveries became known, the whole civilized world was seized with admiration, and the curiosity to witness his experiments became universal. The phenomenon was designated as *galvanism*. Although Galvani's opinion was held by numerous partisans, Volta victoriously refuted it, and demonstrated that the pretended nervous fluid was nothing else than ordinary electricity for which the organs of animals might serve as conductor, and of which they might even be generated. Galvani never yielded to these arguments of his adversary, and refused to abandon his theory up to his death. Although he really made a great discovery, he left Volta to reap the important fruits of it. At the very moment when Galvani was immortalizing his name, he was obliged to undergo the most cruel blows of destiny; for he lost his dearly beloved wife, Lucia Galeazzi, and a short time afterwards had the misfortune to be ordered by the Cisalpine Republic to take an oath which was entirely contrary to his political and religious convictions. He did not hesitate a moment, but promptly refused to take a vow which was repugnant to his feelings, and permitted himself to be stripped of his positions and titles. Reduced nearly to poverty he retired to his brother's house, and soon fell into a state of lethargy from which he could be aroused neither by medicine nor by the decree of the government, which, out of respect for his celebrity, restored to him his position as professor of anatomy at the University of Bologna. But the great physicist died without having again occupied the chair which he had rendered so illustrious.

PEARL INLAYING ON IRON.

THE method by which pearl inlays are made upon enameled or japanned cast or sheet iron is very simple, and at the same time the results obtained are very striking.

Cast and sheet iron and *papier mache* are the materials upon which pearl is generally laid. If the article be of cast iron, it is well cleaned from the sand which usually adheres to the casting, and is blackened with a coat of varnish and lampblack. When this is thoroughly dried, a coat of japan or black varnish is spread evenly upon it. Before the varnish becomes too dry, pieces of pearl cut in the form of leaves, roses, or such flowers as the fancy of the artist may dictate, or the character of the article may require, are laid upon the varnish and pressed down with the finger, and they immediately adhere to the varnished surface. The sheets of pearl may be obtained so thin as to be more like paper than anything else. After the pieces are in place the work is put into a heated oven and kept there for several hours, or until the varnish is perfectly dried. It is then taken from the oven and another coat of varnish applied indiscriminately on the surface of the pearl and the previous coating, and again placed in the oven to dry. This process is repeated several times, until the thickness of the varnish is such that the top of the pearl is level with the body of the varnish, which is then scraped off the pearl with a knife, and the surface of pearl and the varnish around it are found to be quite even. The pearl is then rubbed with a piece of pumice-stone and water, and the surface of the varnish is rubbed smooth with powdered pumice-stone, moistened with water.

It is in this unfinished state that the pearl has the appearance of being inlaid, and from which it derives its name. It is, in fact, inlaid in the varnished surface, to which it adheres with surprising firmness. Its final beauty and finish depend altogether on the skill of the artist under whose hands the shapeless and almost unmeaning pieces of pearl are made to assume the form of beautiful flowers, leaves, etc. The artist traces the stems and leaves of the flowers with a camel's hair pencil dipped in a size made of varnish and turpentine; upon this he lays gold leaf, which adheres where there is size, and the superfluous gold is carefully brushed off with a piece of silk. The flowers and leaves are then painted in colors, and when dry the picture and surface of the article are covered with a coat of refined white varnish. One point should be observed, which is too frequently forgotten by those who paint upon pearl in this country, and that is to use only transparent colors when painting on the pearl itself. This is the secret of the great brilliancy obtained in most of the European work upon pearl.

The kinds of pearl used are three—mother-of-pearl, in the pearl oyster, or white pearl, as it is called by the artist, and it is known by its clear white surface; aurora shell, which can readily be told by its wrinkled appearance and its various prismatic colors, and is made from the shell of the genus of *Mollusca* known as the sea-ear or ear shell, and known to the conchologist as *Haliotis;* the green snail shell, which can be told by its glistening colors of light and dark green, or soft yellow and bright beautiful pink, blended together.

To manufacture the pearl ready for inlaying, the workman cuts the rough shells in pieces with saws, and then grinds the pieces upon both sides upon a common grindstone until they are of the requisite thinness. Out of these pieces the artist cuts the forms of leaves, flowers, etc., with a pair of common scissors preparatory to placing them in the varnished surface. The necessary forms may be cut from the thin pieces of pearl by means of a punch and dies, with power applied by the foot of the operator. When a number of pieces are required of the same size, the pieces may be fastened together with glue as one solid plate, and then the required form marked upon the outside one; then these being held in a vise, the form can be carefully sawed out with a fine saw. By placing the cemented pieces in warm water, the glue softens, and the shells are easily separated and the glue washed off. The artist is no longer under the necessity of preparing the shells for himself, as they can be obtained all ready for use at almost any artist's material store in the country.

This art of inlaying is not confined to the representation of flowers alone, landscapes, with houses, castles, trees, churches, and bridges are very easily made, and when represented as being seen by moonlight are very beautiful. The rising moon can be represented surrounded by clouds of gold and silver bronze, and when pieces of pearl are placed in certain positions to reflect their colors, the moonbeams are represented as glancing over the landscape in alternate light and shadow.

A varnished surface can be ornamented by transferring drawings or engravings to it, and the process is quite simple. A thin coat of copal varnish is spread upon the surface of the article, and when nearly dry the engraving is applied with its face downward and carefully pressed to exclude all air bubbles. When the varnish is sufficiently dry, the paper is thoroughly moistened with a sponge dipped in warm water, and the paper can be rubbed off, leaving all the lines of the print upon the varnished surface.

STILL ANOTHER LETTER COPYING PROCESS.

HERR ADLER has communicated to the Vienna Photographic Society a multiplying process based upon the use of the *glue plate*, consisting of gelatine, glycerine, and water (though the last-named ingredient is present in a smaller quantity than usual), used in the hektograph and other similar processes. For writing or drawing, Herr Adler uses a concentrated solution of alum, to which, in order to render the writing or drawing visible upon the paper) a few drops of some aniline color are added. Before laying the writing or drawing upon the gelatine surface pass a damp sponge over the latter, and allow the moisture to sink in for a few minutes so has to have a greater effect upon the alum. Then lay the written side downward upon the gelatine, and after the lapse of a few minutes, on removing it, the writing will be found reversed and eaten into the gelatine film as if it were engraved. By means of an India-rubber roller a little common printing ink is spread over the plate and absorbed by the lines sunk by the alum, and again rejected on the application of moisture upon the paper laid down upon it, and smoothed over it by the flat hand. When removed this paper will have upon it the first impression of the writing or drawing. For each succeeding impression the plate must be inked, as in lithography, by the India-rubber roller. A considerable number of impressions can be taken.

THE HEIGHT AND SPAN OF THE JAPANESE.

WE well remember that quaint little group of two-sworded, strangely-dressed men who, in the 1862 Exhibition, were pointed out as ambassadors from that then almost *terra incognita*—Japan. The curious would saunter past these eastern islanders in order to form a comparative idea of the height of men whose ample skirts made their height appear greater than their, in truth, diminutive stature warranted. China has since sent us for exhibition the gigantic "Chang;" but Japan, though puzzling us with its clever legerdemain and fascinating us with beautiful *objets d'art*, has as yet not shown us that it can produce men of fine growth. Possibly the Japanese agree with Shakespeare, that "small herbs have grace," whilst "ill weeds grow apace," for it would appear that many of the probable causes of their smallness are directly due to their own agency.

The data that we have for estimating the height of the Japanese are more exact now than the rough measurement above alluded to. Mrs. Chaplin Ayrton, M.D., has recently published* the results of nearly three hundred observations of the height and span of the Japanese. She found the average height to be 5 feet 3 inches, and their span 4 feet 11 inches. In the case of twenty-four women, taken at random, the tallest was a trifle over 5 feet 2 inches, and the average was 4 feet 8 inches, with an average span of 4 feet 6 inches. The shortness of the span as compared with the height is a general characteristic that is especially marked in the case of the women. This gives rise to the theory whether the habit of raising the shoulder-pole for carrying burdens, and the universal practice of tying the infant to the back, may not—by making the arms unused to great muscular exertion—arrest, in a measure, their development.

From the tables of height given the Japanese appear to be not only much smaller than the western nations, but also less variable in height. This may possibly be due to a less

* "Recherches sur les Dimensions Générales et sur le Developpement du corps chez les Japonais."—Thesis for the degree of Doctor of Medicine presented and sustained by Mrs. Chaplin Aryton before the Faculty of Medicine of Paris.

great mixture of races than now exists in Europe. During four years Mrs. Ayrton appears to have only seen one Japanese who struck her as exceptionally tall, a circumstance that in any European capital could not have failed to happen more frequently. Taking the percentage of the observations, 60 per cent. of the Japanese observed had the span shorter than their height, 33 per cent. had the span greater than their height, whilst in only 6·8 per cent was the ideal of proportion realized, namely, that the height and span shall be equal. It is to be regretted that the more complex measurements of the head, etc., were not taken, but possibly the docility of the subjects experimented upon would not have admitted of very detailed examination, as it seems the Japanese have a strong superstitious dislike to be measured, and even object frequently, on the same grounds, to be photographed.

In seeking the explanation of the smallness of the Japanese it is proverbially known that climate is often called to account. Doubtless climate has much to do with the stunted growth of Laplanders and Esquimaux, but Japan occupies a temperate zone. Granted, however, that the climate of Japan is magnificent, still the seasons are more marked and the variations of temperature more sudden than with us, and the question arises whether the sudden demands made upon the organism to accommodate itself to such variable atmospheric conditions may not be unfavorable to harmoniously continuous growth. The clothing of a nation illustrates very fairly the conditions under which they live, and in Japan we find the system of dress to consist essentially of many layers of similarly made garments, the characteristics of which are that, being loose and having one tie each, they can be readily taken on and off; and the abdomen is protected by a long and thick sash. In all variable climates, as in Spain, great advantage has been found to result from keeping the middle of the body well protected. The Japanese of the upper classes usually peel themselves of layers of their loose clothing towards the middle of the day, resuming the garments as evening closes in; whilst the cooly, whose wardrobe is less extensive, casts towards noon his cotton dress in favor of his tattooed skin, and is to be seen in the evening only comfortable in a wadded coat.

The use of charcoal braziers is probably an unhealthy custom; for although Japanese rooms are habitually open to the air in the daytime, still the custom of sitting for many hours with the mouth almost directly over the brazier cannot but lead to a considerable amount of the poisonous oxides of carbon being inhaled.

The physique of the Japanese does not tend to inspire confidence in a vegetarian *régime*, upon which, with fish, this people may be said to live. However, they also eat their vegetables highly salted; and we know that sailors who, under otherwise healthy conditions, yet eat much salted food and live in an atmosphere impregnated with salt, are usually of a short square build. Thus it may possibly be the salted nature of the food, rather than the absence of meat, that is deleterious to growth. Again, with regard to diet, the growth of the children appears to bear a favorable comparison with European children in infancy, when they are nursed even up to three years old, but to become unsatisfactory during the later period of childhood, seeming to indicate that the food supply—although equal to the demand for simple existence—is insufficient during the period of the body's most active growth. It seems probable that the direction in which the food is insufficient is in fatty matters, for, as regards the nitrogenous element, beans, which contain much vegetable albumen, are largely consumed by the Japanese. Of course, however, many of the additional causes of the smallness of the Japanese may be so remote as to cease to affect the nation except by hereditary influence. It appears that authors are agreed that the Japanese are a mixed race. Hilgendorf states that at least one-third of the Japanese skulls are provided originally with a double jugal bone, which remains more or less at a later period, and which might almost be called the "os Japonicum." We know of no observations that connect this cranial peculiarity with the type of face to which it belonged during life; but if, as Mrs. Ayrton thinks, the Malay, Chinese, and Aino types can in the modern Japanese be detected by practice and attentive observation, it might be possible, and would be most interesting, to ascertain to which national element might be attributed a peculiarity which so careful an observer as Hilgendorf considers so indubitable a characteristic of such a large portion of the people of Japan.

This thesis of Mrs. Chaplin Aryton brings us back to the history of the attempt made by women during the last ten years to obtain a higher education. In 1869 the University of Edinburgh opened its matriculation examination to women as well as to men, and five ladies passed this examination, and became each a "Civis Edinensis." But to pass the various examinations at the University of Edinburgh, not only is a certain standard of knowledge necessary, but the candidate must produce certificates of having attended certain courses of lectures within the walls of the college. Joint classes of men and women were, however, specially forbidden by the faculty, and separated courses for so few women were unattainable. Hence after a four years' residence—during which the five and some other girls who had now joined them had, in open competition with the men students, obtained prizes and scholarships, not only at the University, but also at the Royal College of Surgeons, Edinburgh—the small band of women dispersed, many with their well-earned laurels, but all without the much-coveted but unattainable degree. One of them, the writer of the thesis we are reviewing, went as a pioneer to Paris, to see whether there she could obtain the medical education denied her in her own country. In recognition of her four years' academical course at the University of Edinburgh, the Paris Faculty awarded her the honorary degrees of "Bachelier ès Sciences" and "Bachelier ès Lettres," and allowed her to commence the complete course, which, after her subsequently passing the necessary seven examinations, has now been concluded by the award of the degree of Doctor of Medicine on her presenting and sustaining her thesis.—*Journal of Science.*

THE LACE MANUFACTURE OF CALAIS.

THE manufacture of lace goods by machinery, which at present is of considerable importance at Calais, or rather in its suburb, St. Pierre, dates from the year 1816, when the first loom was surreptitiously imported from England, for, at that time, a prohibition against the export of machinery existed. At present two or three of the oldest factories of Calais date from 1825.

During the reign of Louis Philippe the manufacture of lace spread to other towns, such as St. Quentin, Douai, Lille, and Lyons; in the latter town, especially, where most of the silk tulle was then made, while Calais and St. Pierre made lace goods of all textile fibers, including silk, worsted, and cotton, but its chief production at that time was curtains.

At the time of the Anglo-French treaty, Calais had 633 looms, while there were 6,000 at Nottingham, England; this number rose to 939 in 1870, while more than 419 looms were running in the other places in France, and these mostly on coarser goods. This increase of the number of looms in Calais was principally caused by the manufacture of silk lace, to which since then its attention has been principally devoted, for here the French could meet the English manufacturers even-handed.

At present Calais, with St. Pierre, possesses 1,600 looms, valued at £720 each, with all accessories, or including buildings, etc., at £880 each, thus representing a capital of £1,600,000. These 1,600 looms are distributed amongst 430 manufacturers, who produce annually about £2,000,000 worth of goods, of which three-quarters are silk and one quarter cotton goods, a great part of which is exported. These looms give employment to 1,000 hands working on silk, and 600 working on cotton, while only three or four remain for worsted laces.

The silk used comes mostly from Lyons, and ranges from No. 20 to 340, while silk waste is used from No. 4 to No. 80, French counts. The cotton goods are made of two-fold yarn, ranging between No. 40 and No. 340, English counts, and even higher. The goods made of cotton are mostly imitation Valenciennes, torchon, point lace, Malines or Brussels, bobbinet, etc.

The price of the raw material forms generally one-half of that of the manufactured articles, both in silk and in cotton, though in the latter it sometimes is considerably more, as, for instance, in bobbinets, where it mounts up to 70 per cent. For this reason there are only 30 looms running on the latter fabric, while there are 500 in England.

Each loom gives employment, including all accessary labor, to about 20 persons, which makes a working population of 32,000 hands depending upon this industry.—*Textile Manufacturer.*

[Continued from SUPPLEMENT, No. 223, page 3556.]

WHY DOES STEEL HARDEN?

BY WILLIAM METCALF, C. E.

IN order to settle the question of restoring "burned steel," so called, and also to determine the reverse action due to annealing, Prof. Langley took the six pieces No. 1 of Table II., and heated them all to a high yellow heat; he then allowed them to cool very slowly.

This raised a heavy scale on the pieces, which was removed by touching them on an emery wheel.

The specific gravities of these pieces were then taken, and the results are given in the table.

The restoration to the sp. gr. of the bar is complete, as the differences are only such as might be due to the scale on the original bars, and the removal of the scale from the annealed pieces. This will be shown farther in Table IV.

If subsequent trials prove this deduction to be correct, it is very important. Desiring to fortify himself as to this matter of hardening at such a temperature, Professor Langley again boiled the pieces and allowed them to cool very slowly, thus annealing them. The results are given in column No. 3.

Here is a progressive reduction of sp. gr., showing that cold hammering as well as cold rolling reduces sp. gr. The restoration of the sp. gr. of 3 and 4 to the results in column No. 1 shows that there was a hardening due to quenching from boiling temperature. The column of differences 3 and 2 shows the effect of hardening. The column of differences 3 and 1 shows the effect of removing the scale. This column also accounts for the increase of sp. gr. shown in the "restored," or annealed pieces of No. 1, Table I., recorded in Table III. The results recorded in Table IV. have an important bearing on the inquiry into the cause of hardening, which will be shown later. They are also important as showing the entirely mercurial, or thermometric nature of steel. They also indicate a mode of accurate determination of the variable rate of change of volume in steels of different composition.

It will be remembered that there is such a variable rate of change clearly shown in Table I., and farther evidence will be given in Table V.

Now, by operating upon different samples by boiling and sudden cooling in water of uniform temperature, we can get results which will range between certain uniform and known temperatures for each experiment.

TABLE V.

CHANGES IN VOLUME BY REPEATED HARDENING.

No. of times hardened.	No. 6 and 7, Table I. C.=about 0·848	No. 4, Table I. C=0·649.		No. 3, Table I. C=0·529.	
	Contraction of hole.	Expansion.	Contraction.	Expansion.	Contraction.
1	0·00172	.....	0·00257	.....	0·00086
2	0·00172	.....	0·00086	.....	0·00172
3	0·00688	.....	0·00482	.....	0·00000
4	0·00688	.....	.....	0·00172	
5	0·00688	0·00172	.....	0·00086	
6	0·00000	.....	0·00172	0·00086	
7	0·00344 cracked.	not cracked.	0·00000	not cracked.	0·00086
Total change.	0·02752	.....	0·00771	0·00000	0·00000

Hole was originally 0·75 diameter.

This is an experiment to find by measurement the effect of repeated hardening upon three pieces of steel containing different amounts of carbon.

A hole about 0·75 in. diameter was drilled in the middle of each piece. The measurements were taken by means of a tapered plug, the differences in the distance to which it entered in each case after the first and subsequent hardenings was measured by micrometer. The left hand column gives the numbers of the successive hardenings. The other columns show the changes in the diameter of the hole. The first piece, of carbon 0·848, showed contraction of the hole every time it was hardened except the sixth, and the piece cracked at the seventh hardening. The operator supposes the sixth hardening was accidentally omitted.

The second piece, of carbon 0·649, showed contraction three times, then no change. Then an expansion of the hole, followed by a contraction, and the seventh time there was no change. This piece did not crack.

The third piece, of carbon 0·529, showed two contractions, then no change, followed by three expansions, and seventh a contraction. This piece did not crack.

The total changes are quite marked:

Showing for carbon.....0·848=0·02752 in.
" " " .....0·649=0·00771 in.
" " " .....0·529=0·00000

This shows in another way that steel of high carbon changes more in volume per degree of temperature than steel of low carbon.

The high steel cracked, the low did not. All of the pieces were of the same quality.

The experiment recorded in Table No. V. forms no part of the investigation by Prof. Langley and ourselves. It was made rather crudely for a practical purpose, and the results obtained in practice confirmed the figures in the table.

This ends our record of facts and brings us to—

4.—A statement of some of the theories which have been given as the cause of hardening.

Perhaps the oldest, one of the most plausible, and possibly the true reason, is that unhardened steel contains carbon in graphitic and uncombined form, and hardened steel has its carbon all combined.

For proof it is stated that when unhardened steel is dissolved, the insoluble residue contains flocculent graphitic carbon; and when hardened steel is dissolved it leaves no residue of carbon; therefore, the carbon has been combined in the hardening. To answer the objection to this, that it is impossible for iron and carbon to combine in all proportions, one writer states that there is formed a definite carbide FeC_4.

That this carbide is excessively hard and that it acts as a cement or glue, and therefore the high carbon steel becomes so much harder than the low carbon steel.

This will be conclusive after the carbide has been separated and thoroughly examined. Meantime, the hardening from boiling temperature is a little puzzling.

Another writer states that solution of the carbon takes place when the steel is heated, and that a great compression

TABLE IV.

DRILL ROD SAMPLES.

Nos.	1 Sp. Gr.	2 Sp. Gr. Hardened.	3 Sp. Gr. Scaled and not hardened.	Diff. 3-2 Effect of hardening.	Diff. 3-1 Effect of scale off in 1 and 3.
1	7·8068	7·818	7·829	—0·011	+0·022
2	7·794	7·812	7·828	—0·016	+0·034
3	7·816	7·790	7·817	—0·027	+0·001
4	7·787	7·765	7·780	—0·015	—0·007

It is well known that cold rolling does not increase the sp. gr. of iron or of steel. To ascertain the effect of cold hammering under the best conditions to increase sp. gr., viz.; by hammering between semicircular dies, an experiment was made, the results of which are recorded in Table IV.

A round bar of carbon, about 1·0 per cent., was operated upon.

The bar, as it came from the rolls and unannealed, was 0·682 in. diameter; this is No. 1 in the table.

A piece of the same bar, annealed and pickled, was 0·673 in. diameter; this is No. 2 in the table.

The same bar twice hammered cold, after annealing, was reduced to 0·624 in. diameter; this is No. 3 in the table.

The same bar annealed, and hammered cold four times, was reduced to 0·564 in diameter; this is No. 4 in the table.

Prof. Langley first took the sp. gr. of the four pieces as he received them, 1 and 2 having the roll scale upon them, and 3 and 4 being bright polished, and slowly cooled. The results are given in column No. 1.

In this case No. 3 indicates an increase of sp. gr. due to the cold hammering. Prof. Langley then thinking that the results might have been affected by scale in the first two pieces, then removed the scale and boiled them all in weak potash, and upon removing them from the boiling liquid cooled them rapidly by plunging them quickly into cold water.

Column No. 2 gives the results, and here we have the remarkable fact that sudden cooling from boiling temperature causes a hardening effect, which is shown more particularly in Nos. 3 and 4, where there is a decided reduction of sp. gr.

caused by sudden contraction in cooling is the cause of hardness.

If this be so, and our experiments are correct, then carbon dissolves in steel at the temperature of boiling water.

One writer hastens to inform us that steel hardens because part of the carbon is burnt out in heating, and the rest of the mass is compressed by the sudden cooling. It might afford amusement to demolish this theory, if it would not be a waste of time.

A steel maker of twenty years' practice, says hardening is caused by the carbon assuming the diamond form in very minute crystals.

He gives as a proof, that the hot steel decomposes water, or the cooling mixture, which always contains hydrogen.

The hydrogen combines with the carbon to form diamonds, and this is proved by the fact that the diamond and hardened steel both refract light.

In case water is the cooling medium, the hydrogen penetrates the steel, to form diamonds, while the freed oxygen, conveniently inert, stays on the outside to form a thin film of oxide.

As it is well known that mercury is one of the very best cooling liquids, giving extreme hardness to steel, it is necessary to this theory to show that mercury contains hydrogen.

Again, if steel really hardens upon being quenched from boiling temperature, then water must be decomposed by that temperature.

This diamond theory is very attractive and has received much consideration in our minds, but we are not prepared to consider it proven.

Another writer states that hardening is due to the sudden arresting of the molecular motion that exists in the heated steel, thus causing great tension and resulting hardness. He offers as proof, that hardened steel is weaker and more brittle than unhardened steel, and cites as a very happy illustration the case of hardened glass, which is known to be in a high state of tension. This theory tallies with all of the facts better than any we have seen.

First, it covers all conditions, from the boiling temperature up to the high yellow heat which causes intense hardness and the brittleness of glass.

Again, it is certain that the higher the heat the greater the molecular motion. Also it is certain that from the highest heat we get the greatest hardness and the greatest brittleness.

Finally, the restoration of grain, and of sp. gr. by annealing, agree well with the idea of tension in one case, and the relief from tension in the other.

It is possible, even if this tension theory be accepted as correct, that there may be in connection with it a change to diamond form, or from graphitic to combined carbon, and the formation of a definite carbide. Some one of these changes, taking place at a given temperature, may be just what is needed to explain that very remarkable phenomenon known as "refining."

In mentioning a few practical considerations to be drawn from what has been said, it is hardly necessary to address the unfortunate smith and temperer; they, poor fellows, have heard so much of uniform heating and low heating that they may well feel heart-sick and determined to do as they please anyhow.

Let them do as they will they will never be allowed to forget that same old cry—"too much heat"—"irregular heat," and so on.

Let that cry continue; it has its uses, and let us look at the engineer's side.

As steel advances with irresistible steps into the field of construction, the engineer naturally asks, What am I to do with it?

Can it be worked safely?

Is it reliable?

Shall I use high steel or low?

How is it to be worked?

Is it safe to use the apparent advantages of great strength to be had in high steel?

Is it necessary to anneal finished work? etc.

We think it has been clearly shown:

1. That a good soft heat is safe to use if steel be immediately and thoroughly worked.

It is a fact that good steel will endure more pounding than any iron.

2. If steel be left long in the fire it will lose its steely nature and grain, and partake of the nature of cast iron.

Steel should never be kept hot any longer than is necessary to the work to be done.

3. Steel is entirely mercurial under the action of heat, and a careful study of the tables will show that there must of necessity be an injurious internal strain created whenever two or more parts of the same piece are subjected to different temperatures.

4. It follows that, when steel has been subjected to heat not absolutely uniform over the whole mass, careful annealing should be resorted to.

5. As the change of volume due to a degree of heat increases directly and rapidly with the quantity of carbon present, therefore high steel is more liable to dangerous internal strains than low steel, and great care should be exercised in the use of high steel.

6. Hot steel should always be put in a perfectly dry place of even temperature while cooling. A wet place in the floor might be sufficient to cause serious injury.

7. Never let any one fool you with the statement that his steel possesses a peculiar property which enables it to be "restored" after being "burned;" no more should you waste any money on nostrums for restoring burned steel.

We have shown how to restore "overheated" steel.

For "burned" steel, which is oxidized steel, there is only one way of restoration, and that is through the knobbling fire or the blast furnace.

"Overheating" and "restoring" should only be allowable for purposes of experiment. The process is one of disintegration and is always injurious.

8. Be careful not to overdo the annealing process; if carried too far it does great harm, and it is one of the commonest modes of destruction which the steel maker meets in his daily troubles.

It is hard to induce the average worker in steel to believe that very little annealing is necessary, and that a very little is really more efficacious than a great deal.

Finally, it is obvious that as steel is governed by certain and invariable laws in all of the changes mentioned, which laws are not yet as clearly defined as they should be, nor as they will be; nevertheless, the fact that there are such laws should give us confidence in the use of the material, because we may be sure of reaching reliable results by the proper observance of the laws, therefore there is no good reason why engineers should be afraid to use steel if they manipulate it intelligently. Now, if we have wandered over a wide range in answer to the simple question, "Why does steel harden?" it was necessary to have looked at many facts before we could have an intelligent opinion of many theories; and if any are in doubt as to what is the correct answer to this momentous question, we can only say that we are all in the same boat, for if you do not know, neither do we.

DISCUSSION.

JAMES PARK, JR., of "The Black Diamond Steel Works," being called on by the president to open the discussion on Mr. Metcalf's paper, said:

I regret another engagement for this evening prevented me from arriving in time to hear the reading of the paper from its commencement, but having listened attentively to the closing pages, I am sure the society will feel encouraged in finding its first meeting opened under such favorable auspices.

I hail with pleasure such papers as the one we have just listened to, and thank its author and the firm with which he is connected for the care and trouble taken in its preparation, and for the liberality incurred in making the extended experiments and investigations referred to in the paper.

We should feel under obligations to Mr. Metcalf for the interesting information imparted, as the line of experiments and investigations is new, and the publication of the paper will, doubtless, lead others to venture in the same direction, and extend their investigations, covering the various formulas relating to the manipulation of steel, such as the effects produced by heating, hardening, tempering, hot nicking, etc.

My invariable rule, Mr. President, is to tell as little as possible of what I think I know in relation to cast steel, with the view of creating the impression that I know considerable; yet I may say that the various characteristics, and what the workmen call "burning steel," are the most difficult problems I have ever encountered.

The steel maker of twenty years' practice, to whom reference was made, and whose opinion is that hardening is caused by carbon assuming the diamond form in very minute cystals, must have referred to "Black Diamond steel." His theory that the hydrogen combines with the carbon to form diamonds, and that this is proved by the fact that the diamond and hardened steel both reflect light, may, so far as it relates to Black Diamond steel, be correct, because it has been found that those who purchase this brand accumulate wealth "in its using," which is valuable as diamonds. Yet I am free to confess that the light reflected from this steel, when hardened, is not sufficiently glaring to enable the observer to see the diamonds; but this may be accounted for by the crystals being so very minute.

While I do not propose to express an opinion in relation to the question, "Why does steel harden?" I will quote Mr. Metcalf's "last words" in answer to this momentous question, "If you do not know, neither do we."

Sufficient care in heating, hardening, and tempering cast steel is of greater importance than supposed by many who have charge of its manipulation.

It should be impressed upon all who superintend the heating, hardening, and tempering of this important metal, that the element free oxygen, not the heat secured by the combination of oxygen and carbon, produces the many bad results which usually are blamed upon the steel.

With an experience of many years in the manufacture of cast steel, endeavoring to understand its peculiarities, and the danger it encounters when in the hands of the workmen, I have listened to many theories, most of them from educated men, but the first time I was "hugely" gratified was some years ago, at the workshops of the Baltimore and Ohio Railroad Company, when the question was asked by one of the workmen in the smith shops, "Has not the *wind* a great deal to do with injuring steel?" That question came from a hard-working, clear-thinking man, without much "book knowledge." My answer was, "Yes, the wind, or blast, has *all* to do with it; the heat, but little or nothing." I was so greatly pleased with the intelligent question that my first inclination was to embrace that hard-fisted workman; because, after years of "talks with workers of steel," on the subject of oxidizing the carbon of the steel when heated, by allowing the free oxygen of the blast to come in contact with it, this man was the first I had been able to find whose intelligence prompted him to blame the *wind* and exonerate the heat and steel.

Mr. JACOB REESE said that he considered Mr. Metcalf's paper as one of the most important bearing upon hardening, tempering, and annealing steel that he had ever listened to, and was especially pleased to know that after the important tests made Mr. Metcalf favored the molecular theory. Professor Tyndall has said: "Temperature is the measure of molecular velocity as weight is the measure of ponderable matter." According to this theory the ultimate initial particles of matter are not in absolute impact, nor are they in an absolute state of rest at any time. The particles are endowed with two imponderable physical agents which are the prime factors of nearly all the physical and chemical phenomena exhibited in nature. It will be conceived that if the particles are held apart by these agents, there must exist certain cavities between adjacent particles. These cavities are known as physical pores. The atoms unite and form molecules; the molecules unite and form the physical structure. Therefore there is an atomic physical pore, and a molecular physical pore.

I cannot account for the phenomena due to carbon in iron on the hypothesis of a chemical union, as the phenomena cannot be accounted for under the law of chemical equivalents. I believe that the carbon which is said to be chemically combined inhabits the atomic pores, and that the portion known as graphitic inhabits the molecular pores. As the physical pores are limited in area, so is the amount of carbon which the iron will take in limited. The atomic activity at a high temperature is so great as to cause the carbon to exude from the atomic to the molecular pores. And in cooling the velocity is reduced so that the atomic pores again become saturated. The molecular resultant force of pure iron will only resist a tensile strain of 50,000 lb. to the square inch, but if we incorporate one per cent. of carbon with such iron it will resist 150,000 lb. tensile strain, and any modicum of one per cent. in proportion. If it be conceived that the force of attraction is much greater in carbon than in iron, it follows that the accompanying force of caloric must be greater, as these physical agents are always balanced. Now if there is a larger amount of the force of caloric accompanying carbon than accompanies iron, it follows that the molecular velocity of iron will be increased by the addition of every atom of carbon into the mass. And as increased velocity tends to separate the particles the phenomenon of an increased expansion of steel with an increased amount of carbon at any given temperature is accounted for.

Mr. WILLIAM KENT said that Mr. Metcalf had mentioned five different theories in regard to the hardening of steel, and Mr. Reese has given us a sixth. Another theory, which had occurred to the speaker some years ago while studying some phenomena of the brittle alloys of copper and tin, but which he had never found time to develop, may possibly find a place with the other theories, and be left for the future consideration of students of molecular physics. It is that in all brittle materials the position of the molecules is such that lines joining them form the edges of a cube or other solid whose sides are rectangles, while in ductile materials these lines form the edges of a tetrahedron or other solid whose sides are triangles: that is, the molecules are placed as cannon balls are usually piled, in which case a given number of them occupy a much smaller space than if the lines joining their centers formed rectangles. Applying this hypothesis to the hardening of steel, it may be supposed that in hardening steel the molecules take a relative position, such that lines joining them approximately form rectangles, while in the soft steel the lines joining the centers approximately form triangles. The fact that hardened steel has a lower specific gravity than unhardened—that is, that it occupies greater volume, would apparently tend to corroborate this theory. The speaker, however, did not wish to lay any great weight upon this theory, and believed that all theories of this sort have exceedingly small value as compared with the facts which may be handled by the practical man, and such facts as were given in Mr. Metcalf's paper. The facts concerning the specific gravity of hardened and unhardened steel which are given in the tables will remain the data of reasoning it may be for centuries, but the theories may all have to be abandoned as entirely worthless.

Mr. JOHN L. GILL, JR., gave an account of a curious incident which happened in his experience in hardening steel. A piece of high carbon tool steel two and a half inches in diameter and ten inches long was shaped into a knife edge for a testing machine, then carefully heated while inclosed in a gas pipe, and then tempered extremely hard. After being finished, it was laid away upon a shelf for future use. Six weeks afterward it broke in two with a report like a musket shot, and one piece was found five or six feet away from the other. No cause has been assigned for the sudden fracture.

JAMES PARK, JR., said:

I think, Mr. President, that the difficulty encountered by Mr. Gill was brought about by "too careful nursing." To avoid the effects of the blast, he "cradled" the piece of steel within the interior of a piece of gas pipe.

What was the condition of this pipe? How much oxide of iron did its interior surface contain? are pertinent questions. If the tube were or were not hermetically sealed, and its inner surface were coated with oxide, the air in the tube would be sufficient to start an action between the carbon of the steel and the oxide, thereby transferring all the oxygen of the oxide to the carbon of the steel.

The reactions would go on during the heating of the steel, so carefully "cradled" in the oxidized tube, until all the oxide was reduced.

The extent of the action would depend on the amount of oxide in the tube. Even if oxide remained in the tube at the close of the heating operation it would not show that no action had taken place, since iron, reduced at a temperature too low for fusion, immediately oxidizes on the admission of air; we may, therefore, suppose the "gas pipe nursing" resulted in interfering and disturbing the chemical "relations" of the carbon of the steel; and, after giving the steel thus provoked a bath in cold water, heaping insult to injury, it took its own time, and then deliberately "went on a burst."

[Continued from SUPPLEMENT 222, page 3532.]

DYNAMO-ELECTRIC MACHINES.

IN a previous article we have given an outline of the more general part of the research recently made by M. Antoine Breguet, of Paris, on the theory of dynamo-electric machines. Our readers will doubtless remember that M. Breguet starts from two simple principles, viz., that every dynamo-electric machine or generator can be used as an electro-motor or electric engine, and *vice versa;* and that a study of the distribution of the lines of force in their magnetic field will enable us to determine the best conditions for the action of such machines and motors.

We have now to pass on to a consideration of one of the very interesting applications which M. Breguet has made of his theory to the study of the Siemens dynamo-electric generator. This machine is the joint invention of Dr. Werner Siemens and of Herr Hefner von Alteneck. The special feature in it, the armature, with its peculiarly wound coils of which we shall presently speak, is due to the genius of the latter gentleman, and is in consequence sometimes spoken of as "Alteneck's armature" to distinguish it from the earlier and simpler longitudinal armature with cross section like a double headed T, employed in the older Siemens machines.

Not to anticipate, however, we must return to the logical order of development pursued by M. Breguet; and must refer at the outset to the very simple machine figured (Fig. 4) in our former article, in which a single wire bent twice at right angles is made to rotate electro-mechanically between the poles of a horseshoe magnet. A current enters this wire by a mercury cup at one side, and leaves it by a similar cup at the other; the direction of the current through the wire being automatically reversed at every half revolution as the wire swings round, thus alternately attracting up the wire toward the pole of the magnet and repelling it as it passes away on its circular path.

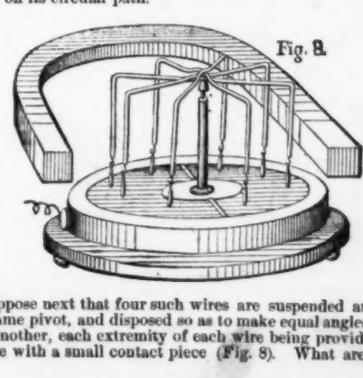


Fig. 8.

Suppose next that four such wires are suspended around the same pivot, and disposed so as to make equal angles with one another, each extremity of each wire being provided as before with a small contact piece (Fig. 8). What are now

the conditions of rotation? A little consideration will show us that if the mercury cups extend as before, and as in Fig. 9, to 180 deg. on each side, the arrangement will be in every way inferior to the one formerly considered; for the current is now shared between four conductors, in each of which there will be but one-quarter of the total current, and they cannot all be situated in the most advantageous position of the field where the attraction or repulsion of the magnet is the greatest. Moreover, some of them will positively be pulled forward while others are pulled backward. So though the current is just as strong as before, the altered distribution of the current is wholly disadvantageous, and the apparatus is both worse and heavier than before. Suppose, however, that the mercury cups are diminished till they subtend, as in Fig. 10, angles of but 90°, only two of the conductors can

Fig. 9. Fig 10. Fig 11.

dip simultaneously into the cup, and one will enter it just as another leaves it. Hence half the current will now traverse each; and if the sectorial mercury cups are judiciously placed so that their edge of first contact lies along CC', which we may call the "diameter of commutation," at right angles to the line joining the magnet poles, the two conductors in contact can never be far from the point where the attractive force of the magnetic field will have the largest effective leverage upon them. Better still will the machine be if the mercurial sectors are still further diminished, as in Fig. 11, down to 45°. Now only one conductor can dip in at once, but it will take the whole current, and as it passes out of contact the next will pass in. The increased weight of the fourfold conductor over the single bent wire of the first arrangement is more than compensated for by the advantage of always having in the most advantageous part of the field that conductor which is being acted upon. Instead of simply receiving an impulse once every half turn, the impulses come eight times during every revolution, and the rotation will therefore be much more uniform.

Once more let us remember what was pointed out at the close of the former article, namely, that every single wire we have considered may be replaced by a coil of many strands, and we shall realize the advance now made toward an efficient electro-motor.

Here, also, we may pause to note that if by the principle of reversibility we use mechanical power to rotate this system of conductors (or "armature" as we may call it), as it lies in the magnetic field, we shall obtain induced currents. And this new generator will possess corresponding advantages over the simpler arrangement that had only one bent wire, inasmuch as it will give both a stronger and a steadier supply of electricity; there being now eight successive currents generated during one revolution instead of two as before, and these currents will be more powerful, since the conductors in which they are generated are being moved through the most advantageous region of the field.

It is of course unnecessary to suppose the contacts to be made by cups of mercury, except that for light experimental bits of apparatus, the freedom from friction thus gained is of service. If the eight ends of these wires were brought down and soldered to a metallic collar on the axis, the collar being slit into eight separate parts, each of which successively came into contact with metallic brushes occupying the position relatively of the sectorial mercury cups, the same end would be attained, though with a little increased friction. With a larger number of conducting wires, the number of segments of the metallic collar or commutator would be increased, and their angular width proportionally diminished. This is in fact the kind of "commutator" which is used upon almost all the dynamo electric generators in use.

We are now prepared to discuss the various systems of winding a Siemens armature. The actual system adopted by Von Alteneck and Siemens is a little complicated. In attempting to explain its nature, M. Breguet devised a simplar system so closely resembling it that he at first thought it identical. He took a single stout wire and bent it up in the manner represented in Fig. 12, the two ends being sol-

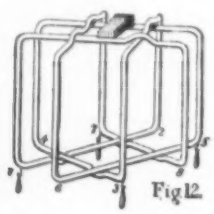


Fig 12.

dered to one another, and the separate bends so insulated as not to touch one another where they cross. Four little contact pieces were added at the corners, 1, 3, 5, and 7, to dip into mercury cups like those of the preceding apparatus, but with quadrantal sectors, as in Fig. 10. Now here the whole current obviously traverses each branch of the conductor, and the rotation will take place with more than redoubled energy; for the impulses will last during a whole quarter of

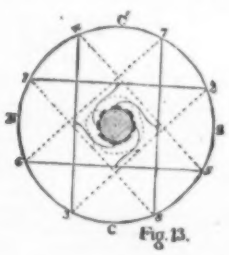


Fig. 13.

a revolution, and there will always be two wires attracted, and two repelled by each pole of the magnet. The same system is represented diagrammatically in Fig. 13, where, however, a metallic collar slit into eight portions is supposed to replace the little contact pieces used for dipping into mercury cups. Of course more than eight vertical wires might be employed. Any regular polygon having an even number of sides would answer; but the octagon with star like points is very simple and effective, and answers all purposes. As before, each single wire of the simple experimental apparatus may be replaced by a coil of many turns; and the whole may be wound upon a longitudinal cylinder or core.

The actual method of winding up the bobbin of a Siemens generator—the method invented by Herr von Alteneck—is represented in a similar diagram in Fig. 14, from which it will be seen that the arrangement adopted has sixteen vertical conductors, and that it is an unsymmetrical one.

Curiously enough, a German engineer, Herr Frölich, who, like M. Breguet, intended to describe the Siemens (or Von Alteneck) armature, discovered another system of winding up the wires, which is shown in diagram in Fig. 15. Here

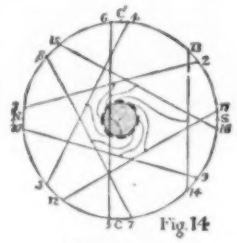


Fig 14

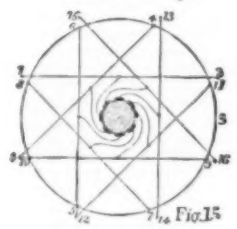


Fig 15

also there are sixteen vertical conductors arranged in pairs at the points of a regular octagon, and crossing the octagon by its diagonals at one end of the armature and by long chords crossing in the form of an eight-pointed star at the other.

There are, in fact, a large variety of ways of winding that coils upon a longitudinal armature, of which that adopted by Siemens is one, and not the best one. M. Breguet says he has found no fewer than eight. Of these there is one which appears to be better than all the others. It is represented in Fig. 16. Its superiority consists in requiring

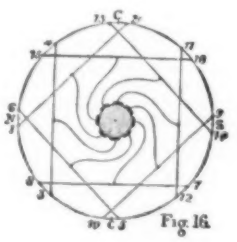


Fig 16.

the employment of a shorter length of wire to attain the same effects; which of course means not only a reduction of first cost, but a saving in the wasteful heating effects of internal resistance. In this system the portions of the coils which cross the ends of the armature to unite the sixteen vertical wires cross the octagon along short chords. As these end portions of the coils contribute little or nothing to the effective work of the motor or generator, it is a clear advantage that they should be as short as possible. M. Breguet has given the following as a table of the proportional lengths of wire necessary to make up end portions of equal sized armatures on the four systems:

System of Herr Frölich (Fig. 15)	30·8
" Von Alteneck and Siemens (Fig. 14)...	30·5
" devised by M. Breguet (Fig. 13)..... .	28·4
" " " (Fig. 16).....	26·0

From which it appears that the last described arrangement is superior to all the others. Mr. Edison's latest generator is simply outwardly a Siemens armature placed between the two cheeks of a powerful upright electro magnet. It is not known yet what system of winding up of the wire he has adopted; though the armature possesses one peculiarity in having a number of strands of iron wire wound transversely between metal cheeks around the core, and the longitudinal coils of insulated conducting wire are wound on outside.

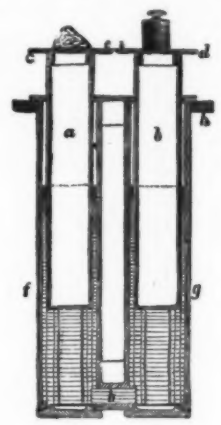
To this elegant investigation of M. Breguet there only remains one point to add, and it will form a fitting peg on which to hang our next and concluding article on the theory of the Gramme machine, namely, that the power of all these machines can be increased not only by increasing the number of turns of wire, and arranging them as advantageously as possible, but by increasing the tensity of the magnetic field in which they move by introducing iron cores into the very middle of the coils.

THE ELECTRIC LIGHT.

EXPERIMENTS are in progress at the North Shore Mills, Liverpool, under the direction of Mr. Ward, engineer of the British Electric Light Company, with the André incandescent lamp, which is said to possess several special advantages. The light is contained in a globe hermetically sealed, and, as the carbon rods are thus protected from contact with the air, they are not subject to combustion, or the combustion is so slow as to be almost imperceptible. The lamp is simple and effective. It is self-adjusting, devoid of mechanical appliances, and, as the carbon points are not consumed, it will remain illuminated for an indefinite length of time. The avoidance of any renewal of the carbon points is an obvious advantage, as is the fact that the new system admits of a complete subdivision of the current of electricity.

HYDROSTATIC BALANCE.

C. WACKERMANN, of Kalk (Prussia), has obtained a patent for the hydrostatic balance of which we give an illustration. It depends upon the well known law that a floating body weighs precisely as much as the volume of liquid displaced by it. Two open parallel cylindrical reservoirs, connected with each other at the bottom, *h*, are partly filled with a liquid, and two equally large and heavy hollow cylinders, a



and *b*, introduced into them. These latter cylinders are provided with top-plates, serving as scale-pans. When not loaded, the pans must be exactly opposite each other. Weighing, of course, is performed in the usual manner. The whole apparatus may be let into the counter or table, *h*, and, if the proper liquid is chosen, is not liable to get out of order.—*Dingler's Polyt. Journ.*

NEW LUMINOUS TUBES.

TRÈVE introduces a Fizeau condenser into a great Geissler tube. The two poles of a current from a Rhumkorff coil terminate in this condenser, by means of the ordinary electrodes, which are soldered into the glass and are attached to the eleventh and twelfth sheets of tin foil. When the induced current passes into the condenser, if the tube still contains air at ordinary pressure, the usual rumbling is heard. If a vacuum is gradually made in the tube, the rumbling diminishes, and when the pressure falls to 0·003 or 0·004 m. (0·118 to 0·157 in.) no sound is heard; but a brilliant white light appears, shimmering like pearls from the leaves of the condenser, and entirely different from the phosphorescent, pale, and flickering light of the Geissler tube.—*Comptes Rendus.*

SIMPLE MERCURIAL AIR-PUMP.

By GEO. M. HOPKINS.

THE strong inclination on the part of experimenters, especially the younger ones, to repeat the brilliant experiments of Geissler, Sprengel, Crookes, and Edison, is apt to weaken when the expensive vacuum apparatus is considered. There are few glass blowers who can make a good Geissler or Sprengel pump, and it would be presumption for an amateur to venture on making this class of apparatus in the ordinary way.

Desiring something simple and inexpensive in the way of an air pump, I devised and constructed the pump shown in the engraving, which is simply a modified form of the Sprengel and Geissler pump as used by Mr. Edison. It was made entirely without the aid of a glass blower, and I may say without any glass blowing. Glass tubes, rubber tubes, corks, sealing wax, and mercury are materials that may be purchased almost anywhere; with these and two one pint nasal douche bottles, a piece or two of board, a few screw eyes, and one or two other articles, the experimenter may begin the task of making the apparatus.

The board, A, 1 inch thick, 14 inches wide, and 54 inches long, has a narrow shelf, *a*, nailed to the upper end; and another similar shelf, *b*, secured to the front side 5 inches from the lower end of the board. A glass tube, B, 8 inches long, and 1 inch internal diameter, is fitted with two corks, *c*, *d*, whose length are about equal to their diameters. These corks are bored to fit the glass tubes which they are to receive, and are coated upon the ends, upon the sides, and in the holes intended for receiving the glass tubes with sealing wax.* A short glass tube, F, $\frac{5}{16}$ inch external diameter, is heated and coated with sealing wax; and while still hot, it is inserted in the hole in the cork, *d*, before the latter is placed in the tube, B. The cork, *d*, is now compressed and forced into the tube, B, leaving a space of $\frac{3}{8}$ inch between it and the end of the tube. The tube, B, is then warmed by turning it carefully in a flaring gas or alcohol flame until the wax on the cork melts, when the space between the outer end of the cork and the end of the tube is filled with sealing wax, as shown in Figure 2, and allowed to cool. A glass tube, C, $\frac{1}{4}$ inch internal diameter, and 32 inches long, is bent at one end at a right angle, to receive the rubber mercury supply tube, D, $4\frac{1}{2}$ feet long. The bending is very easily accomplished by holding and turning the tube in an ordinary gas or alcohol flame until it is soft, when it may be readily bent into the required form. The straight end of the tube, C, is heated, coated with sealing wax, and inserted in the hole in the cork, *c*, so that it comes just even with the upper side of the cork.

After it has cooled, the cork is inserted and secured in the same manner as the cork, *d*. The object in heating the tube, B, after the corks are inserted is to melt the wax on the sides of the cork, so as to cement the cork firmly to the glass and prevent it from being forced inward by atmospheric pressure. A hollow is cut out of the board, A, to receive the tube, B, and the tube, C, is fastened by a copper strap, *f*, screwed to the board and pressing the short section, *e*, of rubber tubing which surrounds the tube, C. A flexible rubber tube, D, is slipped over the lower end of the tube, C, and is connected with the douche bottle, E, containing mercury.

The tube, F, is secured to the board, A, in the same way as the tube, C; and as this method of fastening the tubes is used throughout the apparatus, it will be unnecessary to al-

* A round rod of iron heated and used something after the fashion of a soldering iron will be found convenient for melting and applying the wax.

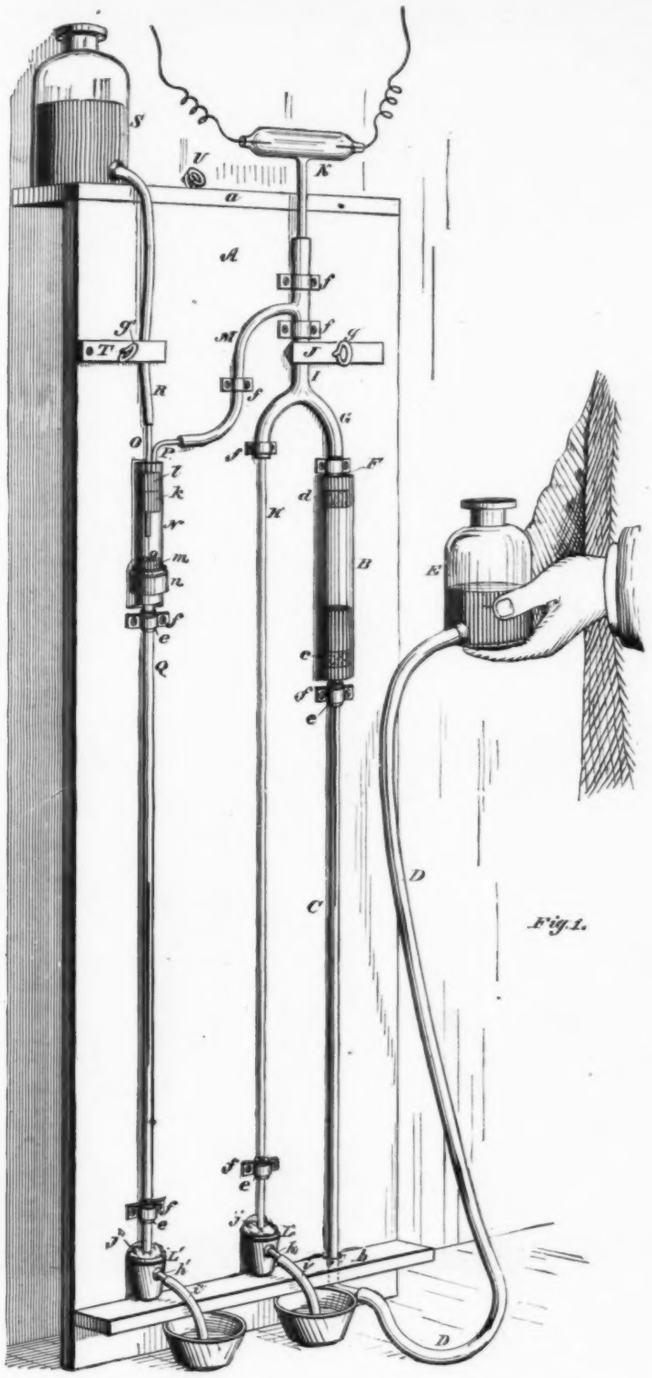


FIG. 1.—SPRENGEL PUMP; GEISSLER PUMP.

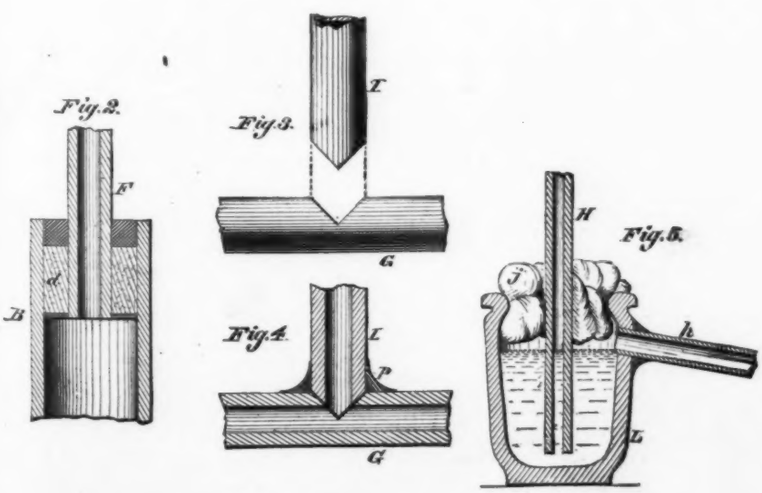


FIG. 2.—SECTION OF GEISSLER PUMP. FIGS. 3 AND 4.—JOINTS.
FIG. 5.—SECTION OF MERCURY RECEIVER.

lude to it again. A very thick rubber tube, G, is slipped over the tube, F, at one end, while the opposite end is slipped over the end of the glass tube, H, which is about $\frac{1}{4}$ inch internal diameter, and 38 inches long. The ends of the tubes, F, H, which are inserted in the rubber tube, G, are varnished with shellac, and the tubes are inserted while the varnish is still green.

In the upper portion of the bent rubber tube, G, a notch

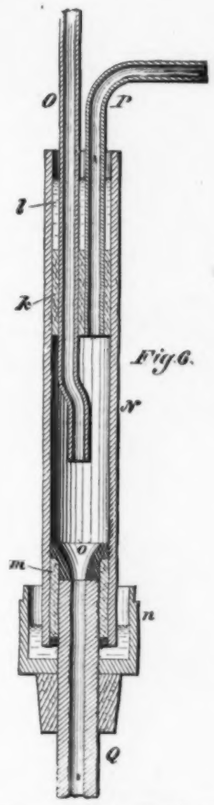


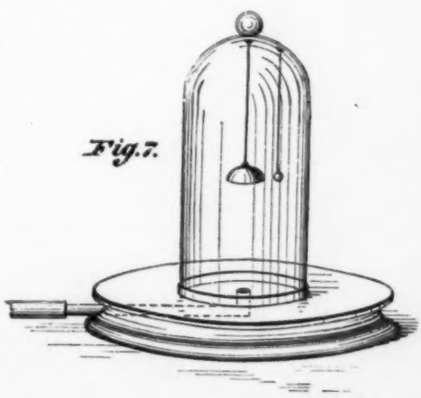
FIG. 6.—LONGITUDINAL SECTION OF SPRENGEL PUMP.

is cut with a sharp knife (moistened with water to facilitate cutting) and the end of a rubber tube, I (6 inches long), is fitted to the notch and cemented in as shown in Figure 4, with a cement composed of equal parts of pitch and gutta-percha melted together and used hot. *p* represents the cement surrounding the joint. The tube, I, extends upward through two copper straps, *f f*, and is provided with a pinch-cock, J, consisting of a bar of hard wood beveled on its inner surface, and operated by an ordinary screw-eye, *g*, which passes through it into the board, A.

The upper end of the tube, I, is intended for receiving a glass or metal tube connected with the vessel, K, to be exhausted. This vessel in the present case is a Geissler tube.

Between the straps, *f f*, a rubber tube, M, is connected with the rubber tube, I, in the same way as the latter is connected with the tube, G; but, for the present, all mention of the tube, M, will be omitted. As the Geissler pump, consisting of the tube, B, and its connections, will be found a very useful instrument when taken alone for many purposes, its construction and operation will be described independently of the Sprengel pump connected with it by the tube, M.

The lower end of the tube, H, dips in a vessel, L, partly filled with mercury. This vessel, in the present instance, is simply a gallipot with a small hole drilled through its side, and fitted with a mercury discharge tube, *h*, furnished with a flexible pipe, *i*, leading to a mercury receiver. Fig. 5 shows the gallipot, L, with its discharge tube, *h*, and the tuft, *j*, of cotton or wool for preventing the mercury from spattering.



The operation of producing a vacuum by means of the Geissler pump just described is to first screw down the pinch-cock, J, by means of the screw-eye, *g*, then raise the mercury bottle, E, until the mercury rises in the tube, C, fills the larger tube, B, flows over the bend in the pipe, G, and discharges through the tube, H, into the gallipot, L. At this moment the mercury bottle, E, is lowered, allowing the mer-

cury column to break in the tube, G, a small portion falling in the tube, H, while the larger portion descends in the large tube, B. As soon as possible after the mercury begins to fall, the pinchcock, J, is opened, and the descending mercury draws the air from the Geissler tube, K. As soon as the mercury has dropped as far as it will, the pinchcock, J, is closed, and the operation is repeated over and over again until the mercury in the tube will stand about 28 or 29 inches in height, measuring from the upper surface of the mercury in the bottle, E, when the latter sets upon the floor.

The smallest amount of mercury that can be used with this pump is 5 lb. It will be obvious that, by enlarging the tube, B, the capacity of the pump may be increased, but if it is made on the plan represented in the drawing, some difficulty

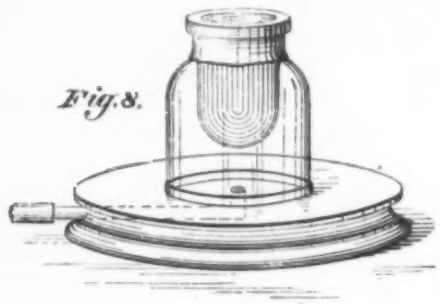


Fig. 8.

may be experienced in making good tight joints at the ends. It would be better to have a vessel made like a bottle, with no bottom, but having a neck on each end into which the tubes, C F, might be inserted. The rubber tubes, G I M, should be thick enough to resist atmospheric pressure when a good vacuum has been formed.

When the Geissler pump alone is used, the rubber tube M, will not be attached. The joint between the rubber tube, I, and the tube inserted in it at the top is rendered perfect by the application of a little vaseline, and this substance may be used to stop slight leaks, should any occur; and should the rubber tubes be suspected of porosity, they may be entirely covered with vaseline.

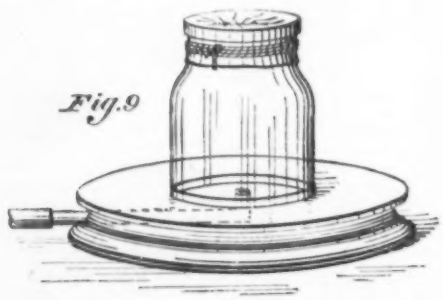


Fig. 9

In working the Geissler pump, the mercury that overflows from the gallipot, L, may be poured from time to time into the bottle, E.

This pump may be used for all purposes in place of the ordinary piston pump, but when a more perfect vacuum is required, the Sprengel pump connected with it by the tube, M must be used.

The Sprengel pump has a tube or barrel, N, 4 inches long and $\frac{5}{8}$ inch internal diameter, in the upper end of which is secured a cork, *k*, through which pass two small glass tubes, O P, about $\frac{3}{16}$ inch internal diameter. The tube, O, is connected by a rubber tube, R, with the douche bottle, S, standing on the shelf, *a*. The tube, R, is furnished with a pinch cock, T, operated by the screw eye, *g*. The tube, O, projects about

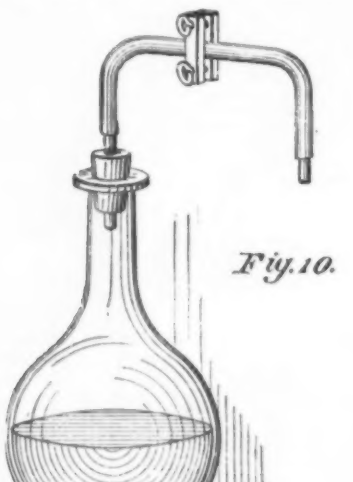


Fig. 10.

$\frac{1}{4}$ inch below the cork, *k*, while the tube, P, passes just through, and is bent at a right angle to receive the tube, M. The cork, *k*, is placed $\frac{5}{8}$ inch below the upper end of the tube, N, to form a cavity, *l*, for receiving a small quantity of mercury, which seals the joint and supplements the sealing wax used in fastening the cork, *k*, and prevents the entrance of air.

The lower end of the tube, O, is bent as shown in Figure 6, to bring it directly in the axis of the tube, N.

A cork, *m*, fitted to the lower end of the tube, N, is bored to receive the glass tube, Q, which is $\frac{1}{4}$ inch internal diameter and 33 inches long. The cork, *m*, is carefully coated with sealing wax, and the tube, Q, is cemented into it; and upon the upper end of the tube and cork a quantity of sealing wax is built up, forming a conical mouth, *o*, for the tube, Q. The sealing wax, when cool, is cut with a penknife into the required form. It may then be warmed quickly over a small pointed flame to give it a smooth glossy surface. The tube, Q, with the cork, *m*, and flaring mouth, *o*, attached, is now inserted in the lower end of the tube, N, and fastened by heating the tube as in the case of the Geissler pump; the lower end of the tube, N, is then carefully sealed around the tube, Q. A common wooden pill box, *n*, bored to receive the tube, Q, and supported by a cork which is bored and cemented to it, is partly filled with mercury to seal the lower end of the tube, N.

The glass tube, Q, is supported in the same way as the tube, C, and the arrangement of the gallipot, L, tubes, *h i*, and mercury-receiving vessel, is the same as in the case of the Geissler pump.

The operation of the Sprengel pump is quite different from the Geissler. It depends upon the continuous dropping of mercury from the lower end of the tube, O, into the mouth, *o*, of the tube, Q. Each drop acts as a liquid piston, carrying downward before it a quantity of air. The flow of mercury is controlled by the pinch-cock, T. When the falling mercury incloses no more air, and the drops strike the top of the mercury column contained in the tube, Q, with a sharp clink, the vacuum is nearly complete.

Five pounds of mercury can be made to work this pump quite well by having two mercury receivers at the bottom, and pouring the mercury back into the bottle, S, as often as it becomes nearly exhausted, but it is better to use 10 or 15 pounds. The Sprengel and Geissler pumps may with advantage be used together, the latter being used for removing the bulk of air, the former being employed in completing the vacuum.

The manner of using the two together is as follows: The Sprengel pump is first started by opening the pinch-cock, T. The pinch-cock, J, being closed, the Geissler pump is worked as before described, but instead of simply exhausting air from the Geissler tube, K, it exhausts it from the Sprengel pump. When the vacuum is sufficient to sustain a column of mercury 28 or 29 inches high in the tube, Q, the Geissler pump is shut off by closing the pinch-cock, J, when the operation is completed by the Sprengel pump.

Supposing the vessel being exhausted to be a Geissler tube, the vacuum is tested from time to time by passing sparks through it from an induction coil. When the proper degree of vacuum is attained, the Geissler tube is sealed off by applying to the glass tube that connects it with the rubber tube a gas or alcohol flame, and pulling and twisting the tube when soft so as to temporarily seal the tube. The tube has a second sealing at the hands of the glass blower.

When the vacuum is such as to prevent the passage of sparks between points $\frac{1}{4}$ inch apart in a vacuum tube it may be considered very perfect. A small Geissler tube is sometimes connected with the vacuum apparatus as a gauge to indicate the perfection of the vacuum.

If desired, all the joints in the apparatus may be sealed with mercury as in the case of the tube, N. Instead of the gallipots wooden pill boxes may be used. They should be well coated with shellac outside and inside.

The success of either of the pumps above described depends in a great measure on having the tubes perfectly clean and upon using clean mercury.

Figures 7, 8, 9, and 10 show some of the common air pump experiments that may be readily performed by using the Geissler pump alone.

Fig. 7 shows a plate having a tube extending from its center to the side of its base to receive a flexible tube connecting it with the tube, I. To the plate, which may be of brass ground to a perfectly level surface, a bell glass is fitted by grinding it with emery and water upon another level surface such as a piece of plate glass. To the center of the top of the bell glass is cemented a silk cord carrying at its lower end a bell. Near this cord is cemented another similar one supporting at its lower end an iron ball which hangs near the bell but does not touch it.

By exhausting the air from the bell glass and then swinging the bell hammer by means of a magnet until it strikes the bell, the fact that rarefied air is incompetent to conduct sounds is at once manifest. The same bell glass may be used for other experiments. To improve the joint between the bell glass and the plate, the latter may be smeared with vaseline.

It is not absolutely essential that the plates or bell glass be ground perfectly true, if a ring of very elastic rubber be used under the edge of the glass.

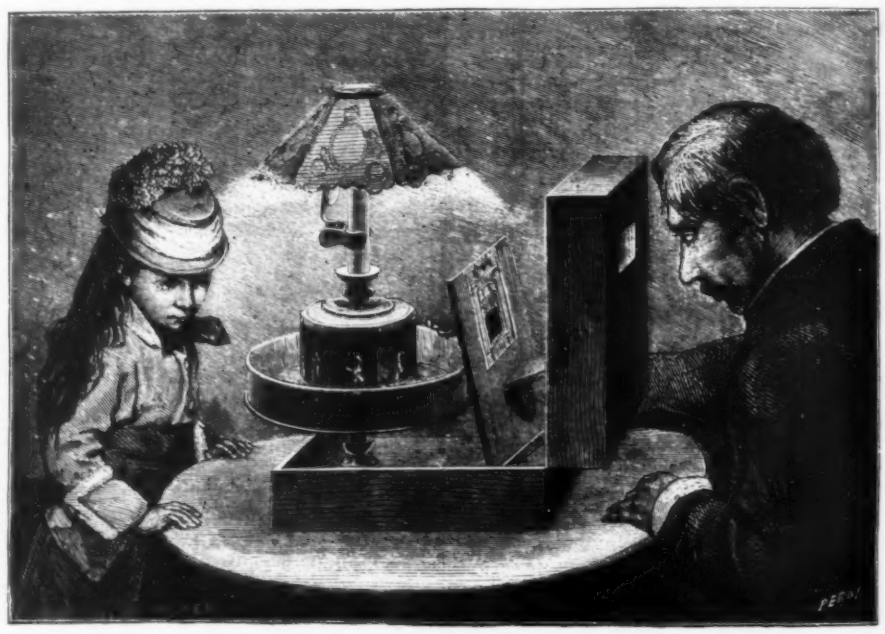
Fig. 8 shows a jar covered with elastic rubber which yields to air pressure as the counter pressure is removed from beneath it by the pump.

Fig. 9 shows the effect of air pressure when the jar is closed with a piece of bladder which is non-elastic. The air pressure in this instance bursts the bladder with a loud report.

Figure 10 shows the arrangement of a flask partly filled with water which is quite warm, but not boiling hot. On connecting this with the pump and removing the air pressure from the surface of the water, it begins at once to boil. Ether will boil at a comparatively low temperature in a vacuum. It is not advisable, however, to perform this class of experiments with the pumps above described, as moisture interferes with their operation; and should any accumulate on the inner surface of the tubes, they should be dried at once by means of cotton wound upon the end of a wire. Although these pumps are easily made and inexpensive, they serve a really good purpose and will doubtless prove serviceable to many readers of this journal.

THE THEATER PRAXINOSCOPE.

M. REYNAUD, the inventor of the "praxinoscope," has recently modified this popular toy so that the moving figures seem to be in relief, and, by the addition of proper scenery, the same effect is produced on the observer as if he were looking in upon a liliputian theater in which living actors were performing. In this new apparatus, which the enventor called the "theater praxinoscope," the figures in their different poses are first sketched on a black ground; then, to obtain the scenic effects, an image of an appropriate design is projected on the black ground by means of a sheet of plain glass. The property possessed by a transparent sheet of plate glass of giving, by reflection, an image of objects situated in front of it, and at the same time of allowing objects to be seen which are placed behind it, is well known; and this same effect of optics has already been made use of in theaters in ghost scenes. In the toy under consideration the scenery is placed in the cover of the box, and this is kept in a vertical position by means of a hook, as shown in the annexed figure. In this cover there is a rectangular opening, through which the spectator (looking with both eyes) perceives at the same time both the moving image of the praxinoscope and the fixed image of the scenery reflected



THE THEATER PRAXINOSCOPE.

on the plate glass. The inclination of the latter and its distance from the scenery are such that this image seems to be behind the moving object, and, consequently, the latter appears to be actually in relief on the stage. The box cover is provided with a slit, through which the scenery is inserted, and a small shelf for it to rest upon. By having on hand, then, a supply of chromos, representing landscapes, buildings, the interior of a circus, etc., it is easy to select a proper scene to accompany each of the different moving objects placed in the praxinoscope. The toy works equally as well in the evening as in the daytime. To use it by daylight it is only necessary to place the apparatus before a well-lighted window; at night the same effects will be obtained by simply placing in the candlestick at the center of the praxinoscope a wax candle provided with a small silvered reflector and a shade. The illusion produced by this scientific plaything is said to be very complete and very curious.

EDMUND HALLEY: HIS LIFE AND WORK.

ON June 12, 1874, Prof. Adams, President of the Royal Astronomical Society, called the attention of the members at the meeting to the original labors of Jeremiah Horrocks in connection with the then forthcoming transit of Venus; the result being the erection of a memorial to Horrocks in Westminster Abbey. Several of those who took then such a keen interest in the noblest of astronomical problems (one of whose keys was about to be unlocked by the keen observers of various nationalities) have passed away; but the veterans who survive, together with an ever-increasing crowd of junior recruits, are now looking forward to the next recurrence of the infrequent transit, and on this occasion we may well devote a page to an outline of the life of the famous Dr. Halley, whose name is so well known, but whose history has yet to be written. For beyond more or less unsatisfactory and inauthentic sketches of his career, no actual scientific biography of our grand countryman exists. The want of such a work will, we believe, be ere long supplied by the Savilian Professor of Astronomy at Oxford, in whose hands the mass of material collected by the late Prof. Rigaud rests; so that the result of the editorial labors of the Reverend Professor Pritchard may be looked for at an early date. Meantime we may briefly recapitulate what is

generally known of the indefatigable and long-lived cosmographer to whom it is now proposed to erect a fitting monument on the site of his deserted station at St. Helena.

Edmund Halley was born at Haggerston, near London, on the 29th of October, 1656, and was the only son of a soap boiler. He was educated at St. Paul's School, and at an early age evinced a peculiar aptitude for mathematics. He first applied himself to the study of languages and sciences, and at sixteen years of age made original observations on the movements of the magnetic needle before he left St. Paul's School. In 1673 his university career commenced at Queen's College, Oxford, where, at the age of twenty, he made careful observations of the spots on the sun, the first results of his study of solar physics, made during July and August, 1676, being published in conjunction with those of Flamsteed.

Young Halley's first ambitious scheme was to make an accurate general catalogue of the stars, and as Hevelius and Flamsteed were employed in cataloguing the stars of the Northern Hemisphere, interest was made with the then reigning monarch, Charles II. (who appears to have been much interested with the ardent enthusiasm of the young astronomer), who permitted Halley to proceed, *at his own expense*, to the nearest available spot under the southern tropic, viz., St. Helena, which small island had been retaken by Sir Richard Munden from the Dutch in 1673, and regranted to the East India Company by a new charter, and a European garrison was raised for its defense under Captain Gregory Field. The educational state of the island in those days may be judged from the fact that three of the few members of the council were unable to write, and could only affix their marks to the proceedings of the Board. The latitude and longitude of the island even were imperfectly known, and the means of ascertaining the latter were so inaccurate on board ship that at least one ship returned to England with the intelligence that the island had disappeared altogether. Halley's journal or log-book of the voyage is still extant, and what is now a matter of a fortnight's steaming in a Union Company or Donald Currie steamer was then a formidable voyage of two or more months (the Northumberland, under Rear Admiral Sir George Cockburn, leaving the Start on the 9th of August, reached St. Helena on the 15th of October, 1815, with Napoleon on board), and we can imagine the enjoyment he must have felt during the tropical nights on the Atlantic, and the first indelible impressions with which he beheld the gradual rising of the Centaur, Argo, Crux, and the Nubeculæ of Magellan, whose pale phosphorescent radiance contrasts with the dark spot through which the terrestrial spectator catches a glimpse of the ultraplanetary depths of space.

Arrived in St. Helena, then overgrown with forests and rare shrubs now extinct for ever, he appears to have landed at James' Fort, in Chapel Valley, late in the year, and must have found no small difficulty in the selection of a site for his temporary observatory; but doubtless tempted by the unusual clearness of the season, he selected a magnificent situation on the northern side of the central mountain, to which he must have had considerable difficulty in transporting his instruments, as even with the present modern roads wheeled transport is most limited and precarious. Under Governor Field, however, with slave labor and royal auspices, Halley industriously set to work toward the completion of the catalogue of the southern stars, and delineated a planisphere of their projection. It was here, says Prof. Forbes, that "Halley was the first to see clearly what a powerful means of determining the sun's parallax an observation of contact really is. So far as I can discover, he first mentions the method in a letter to Sir Jonas Moore, written at St. Helena in 1677,* just after having seen a transit of Mercury. The exactness with which he believed the time of contact to be determinable led him frequently afterwards to urge his countrymen to make every effort to utilize the method on the occasion of the transits of 1761 and 1769, when he should be dead.† And thus, in addition to his celebrated prediction of a comet, he left a second legacy to his successors, who, as Englishmen, might be entitled to be proud of his foresight, though he could not live to reap the glory of it."—("The Coming Transit of Venus," by Prof. George Forbes, *Nature*, April 23, 1874.)

"Halley saw (what many people fail to see even now) that the great accuracy of the method consists in this, that in one second of time Venus moves over about 0·2″; and if we can determine the time of contact, with an error of no more than a second, we are measuring the sun's parallax with an error of no more than 0·02 of a second of arc. Halley even pointed out the best stations for observations."—(*Ibid.*)

Ninety-four years subsequently to this letter Dr. Maskelyne and Mr. Waddington were able to take advantage of Halley's legacy, and to partake in their share of its fruition.

The result of Halley's observations in the Southern Hemisphere, made in spite of the clouds which hung over the heights of the rocky island (caused by the counter-current of air above the trade-winds), was the publication of the positions of 350 stars which he had fixed in his "Catalogus Stellarum Australium."—(See Humboldt's "Cosmos," vol. iii., 207.)

Halley returned to England in 1678, and at the early age of 22 years was elected a member of the Royal Society. On his return to England he whs not idle, for we soon find him at Dantzic engaged in settling a friendly and international controversy between the Royal Astronomer of England and Dr. Hevelius. He was traveling on the Continent with his companion Mr. Nelson when—between Calais and Paris—he made his second (December) observations of the remarkable direct elliptic comet of 1680, the length of whose tail was calculated at 100 millions of miles, with a period of 8,813 years, having observed it before its perihelion passage the previous month.

During a portion of 1681 Halley spent a considerable time in Paris with Cassini at the Observatory, and subsequently went to Italy, where we find a record of him in a first edition of a copy of the "Principia," of his friend Newton, bearing an autograph inscription from the donor to the Abbé Nazari, who edited a scientific journal at Rome at this period. The following is the entry in Halley's handwriting:‡

ILLUSTRISSIMO DNO
DNO ABBATI NAZARIO
ROMÆ HUMILLIME OFFERT
EDM. HALLEY.

During the year 1682 Halley observed and determined the parabolic elements of the retrograde orbit of the remarkable comet of long period which bears his name. The results of his calculations made it evident to him that this comet must have been identical with the comet observed in 1607 by Kepler and Longomontanus, and also with one whose elements were calculated from observations by Apian, at Ingoldstadt, in 1531, and which previously appeared in 1456 and 1378, as calculated by Pingré and Langrier. Halley predicted the return of this comet at the close of 1758 or beginning of 1759—the first prediction of the return of a comet.

This comet, as is well known, actually passed its perihelion on March 12, 1759, just one month before the time calculated by Clairaut, Lalande, and Madame Lepaute; and again on November 15·95, 1835, within five days of Rosenberger's elaborate calculation. We now await the next advent of Halley's comet in 1909–10, its perihelion passage being fixed by the late Count G. de Pontecoulant (as communicated by him to the Paris Academy of Sciences in 1864) to May 23·87 (Paris time?), 1910; it having been last glimpsed by Dr. Lamont with the Munich refractor on May 17, 1836. —(See *Nature*, February 11, 1875, p. 286.)

An account of his next research is given by K., in a paper on the "Early History of Magnetism," in *Nature*, April 27, 1876, p. 523, as follows: "In 1683 Halley presented a paper of great importance to the Royal Society of London, entitled 'A Theory of the Variation of the Magnetical Compass.' In this communication he states that the 'deflection of the magnetical needle from the true meridian is of that great concernment in the art of navigation that the neglect thereof does little less than render useless one of the noblest inventions mankind ever yet attained to,' and gives as the result of 'many close thoughts' the following explanation of the variation of the compass:

"'The whole globe of the earth is one great magnet, having four magnetical poles or points of attraction, near each pole of the equator two; and in those parts of the world which lie near adjacent to any one of those magnetical poles, the needle is governed thereby, the nearest pole being always predominant over the more remote.' He remarks that the positions of these poles cannot as yet be exactly determined, from want of sufficient data, but conjectures that the magnetic pole which principally governs the variations in Europe, Tartary, and the North Sea is about 7° from the North Pole of the earth, and in the meridian of the Land's End; while the magnetic pole which influences the needle in North America, and in the Atlantic and Pacific Oceans from the Azores westward to Japan, is 15° from the North Pole, and in a meridian passing through the middle of California. The variation in the South of Africa, in Arabia, Persia, India, and from the Cape of Good Hope over the Indian Ocean to the middle of the South Pacific, is ruled by the most powerful of all these magnetic poles, which is situated 20° from the South Pole of the earth, and in a meridian passing through the Island of Celebes; in the remainder of the South Pacific Ocean, in South America, and the greater part of the South Atlantic Ocean, it is governed by a magnetic pole 16° from the South Pole in a meridian 20° west of the Straits of Magellan.

"On this hypothesis Halley explains the variation observed in different places, and among others cites the two following instances: On the coast of America, about Virginia, New England, and Newfoundland, the variation was found to be west, being above 2·3° in Newfoundland, 30° in Hudson Strait, and 57° in Baffin's Bay. On the coast of Brazil, on the contrary, it was found to be east, being 12° at Cape Frio, and increasing to 20½° at the Rio de la Plata, thence decreasing toward the Straits of Magellan. Thus, almost in the same geographical meridian, we find the needle at one place pointing nearly 30° west, at another 20½° east; this is explained by the north end of the needle in Hudson Strait being chiefly attracted by the North American magnetic pole, whilst at the mouth of the Rio de la Plata the south end is attracted by the south magnetic pole situated west of the Straits of Magellen. Sailing north-west from St. Helena to the equator, the variation is always in the same direction, and slightly east. Here the South American is the chief governing pole, but its power is opposed by the attraction of the North American and Asian South Poles, the balance as you recede from the latter being maintained by approach to the former.

"During the next nine years Halley continued his investigation of the causes of magnetic variation, and in 1692 he made another communication to the Royal Society, in which he endeavored to meet two difficulties he had always felt in his former explanation; one, that no magnet he had ever seen or heard of had more than two opposite poles; the other, that these poles were not—at least all of them—fixed in the earth, but slowly changed their positions. The following observations are cited by Halley in proof of the motion of the magnetic system: At London, in 1580, the variation was 11° 15′ E., in 1622 it was 6° E., in 1634 it was 4° 5′ E., and in 1657 there was no variation; while in 1672 it was 2° 30′ W., and in 1692, 6° W. At Paris the variation was 8° or 9° E. in 1550, 3° E. in 1640, 0° in 1666, and 2° 30′ W. in 1681. At Cape Comorin it was 14° 20′ W. in 1620, 8° 48′ W. in 1680, and 7° 30′ W. in 1688. Halley considered the external parts of our earth as a shell, separated by a fluid medium from a nucleus or inner globe, which had its center of gravity fixed and immovable in the common center of the earth, but which rotated round its axis a little slower than the superficial portions of the earth. The nucleus and the exterior shell he regarded as two distinct magnets, having magnetic poles not coincident with the geographical poles of the earth. The change observed in Hudson's Bay being much less than that observed in Europe, Halley concluded that the North American pole was fixed, while the European one was movable; and, from a similar observation on the coast of Java, he considered the Asian South Pole as fixed, and the pole west of the Straits of Magellan to be in motion. The fixed poles he regarded as those of the external shell, and the movable as those of the inner nucleus. Of these latter the one placed by him in the meridian of the Land's End was ascertained, in the present century, to have moved to Siberia in 120° E. long., and that placed by him 20° from the Straits of Magellan to have moved between 30° and 40° west of this position; while those poles regarded by Halley as fixed were found but slightly altered in position since his time. It is extremely interesting to find that not only modern observations of declination, but also those of dip and magnetic intensity, have received their best explanation on the assumption of four magnetic poles. Much, however, that is mysterious, remains unsolved, and Halley's remarkable words may even now with truth be quoted: "Whether these magnetical poles move altogether with one motion or with several, whether equally or unequally, whether circular or libratory, if circular about what center, if libratory after what manner, are secrets as yet utterly unknown to mankind, and are reserved for the industry of future ages."—("K.," *ibid.*)

Intent on still further carrying out his magnetic researches, Halley was successful in an application to King William to fit out a scientific expedition, and in 1698, as Capt. Halley, R.N., received his appointment to the command of H.M.S. Paramour, in which vessel, a Pink (?), his sailing orders directed him to seek by observations the discovery of the rule of variations of the compass, and as well to survey and lay down the latitude and longitude of His Majesty's American settlements. The Paramour left England in November, 1698, but was absent only for seven months, on account of sickness breaking out among the crew during their stay in the equatorial calms, and his lieutenant mutinying. On their return home the lieutenant was court-martialed and cashiered; and Capt. Halley, in no way disheartened, and with his expedition augmented by the presence of a smaller consort placed under him, set off in September, 1699, and voyaged throughout the Atlantic Ocean from the Arctic to the Antarctic regions, until the ice stopped his progress. He revisited the well-known scenes of his early scientific success on the isolated rock of St. Helena, which doubtless inspired him with the thoughts of old Robert Herrick, whose lines aptly apply to this now barren spot:

"Rockie thou art, and rockie we discover
Thy menne, and rockie are thy wayes all over.
O menne! O manners! now, and ever knowne,
To be a rockie generatione!
A people currish, churlish as the seas,
And rude almost, as rudest salvages;
With whom I did, and may resojourne whenne
Rocks turn to rivers, Rivers turn to menne."

The voyage of the Paramour included the coasts of the Brazils and the West Indies on the West, together with the West Coast of Africa, Madeira, and the Canaries, etc., and lasted a whole year: the result was speedily made public by the production of the much-cited "Halley's Magnetic Chart" (on which the isogonal magnetic curves or "Halleian linea" were laid down), the original of which is in the British Museum. By the assistance of Mr. Winter Jones, the principal librarian, copies in a reduced size have been produced from this chart, and they were inserted as an Appendix in the Magnetical and Meteorological volume of the Astronomer Royal's Report at Greenwich for the year 1869.

In April, 1701, Capt. Halley was employed as Hydrographer to His Majesty, and surveyed the British Channel, an accurate chart of which was published under his superintendence, besides a systematic series of observations on the tides was undertaken with satisfactory conclusions. By this time the fame of Halley as an astronomer, discoverer, and engineer, had spread throughout the civilized world, and the Emperor of Germany (Leopold), desirous of forming a harbor for shipping in the Adriatic, applied for and obtained from Queen Anne the services of Captain Halley, who embarked for Holland on November 22, 1702, and proceeded to Istria. In consequence of the political opposition of the Dutch, Halley's designs were not carried out as to the construction of two ports in Dalmatia; but the approval of the Emperor Leopold was signified by the present of a diamond ring and an especial letter of recommendation to the Queen of England, who again sent him to Istria, where, in conjunction with the Emperor's engineer, he added to the fortications and harbor-works of Trieste. On this occasion, passing through Hanover, he supped with the Electoral Prince (subsequently our King George I.) and his sister the Queen of Prussia, and at Vienna he was personally presented to the Emperor Leopold.

In 1703 Capt. Halley returned to his native country, and was made Professor of Geometry in the University of Oxford, in the place of Dr. Wallis, and the degree of LL.D. was also conferred upon him. The professorship of astronomy at the University of Oxford was withheld from him, it is said, at the instigation of the orthodox Stillingfleet—another instance of the numerous attempts to stifle true scientific investigation by narrow minded and bigoted divines.

The late Captain, now Doctor Halley, as indefatigable as ever, did not seek in his professorial chair the *otium cum dignitate*; only forty-seven years of age, he began to translate into Latin, from the Arabic, "Apollonius de Sectione Rationis," and to restore the two books "De Sectione Spatii" of the same author (which are lost), from the account given of them by Pappus; and he published the whole work in 1706. Afterwards he took a leading part in preparing for the press and editing "Apollonius' Conics," and he successfully supplied the whole of the eighth book, the original of which is lost. He likewise added Serenus on the Section of the Cylinder and the Cone, printed from the original Greek, with a Latin translation, and published the whole in folio.

In 1713 he was made Secretary of the Royal Society, and on May 3, 1715, with the astronomer De Louville, he made his observations of the celebrated total solar eclipse from the house of the Royal Society, in Crane Court, Fleet Street, which he has so well recorded in the "Philosophical Transactions" of the Society.

In 1720 he was appointed Astronomer Royal at Greenwich, in room of his old friend and colleague Flamsteed; and nine years afterwards had the distinction of being chosen as a foreign member of the Academy of Sciences at Paris.

Full of years and honors this great man died at Greenwich, in his eighty-seventh year, after a long career of such scientific benefits to his countrymen as few of our greatest philosophic worthies can boast. Besides his magnetic works and astronomical discoveries—among which was the discovery of the acceleration of the moon's mean motion, and the method of finding longitude at sea—his principal works were the "Tabulæ Astronomicæ," and an "Abridgment of the Astronomy of Comets," in addition to his "Catalogus Stellarum Australium" before mentioned. We are also indebted to him for the publication of several of the works of Sir Isaac Newton, who had a particular friendship for him, and through whom some of his most important discoveries were made. Thus, for instance, the first evaluation of the mass of Jupiter is that of Newton in the Cambridge edition of the "Principia" (1713), inferred from Halley's observation of an emersion of Jupiter and his satellites from the moon's limb, giving for the denominator of the fraction 1033.—(See *Nature*, September 23, 1875.)

Such is a brief account of the talented Edmund Halley, the details of whose busy and varied life must be awaited with the utmost interest. It will, we are assured, be a source of gratification and pride to astronomers, and indeed to all scientific men throughout the Anglo-Saxon dominions, to unite in raising such a memorial as has been suggested by the organizer* and observer of the Mars Expedition in 1877, and at last we may expect to see Halley's Mount crowned with an appropriate memorial of the astronomer.—*Journal of Science.*

* Hooke's Lectures and Collections, 1678.

† "Catalogus Stellarum Australium;" also "Phil. Trans.," 1694 and 1715.

‡ See *Nature*, March 6, 1879, p. 422.

* David Gill, Esq., F.R.A.S., Astronomer Royal at the Cape.

THE SOLAR ECLIPSE OF JAN. 11, 1880.

Mr. George Davidson, of the United States Coast and Geodetic Survey, gives the following preliminary report of the observation of the late eclipse by the party stationed at Santa Lucia, Cal., almost exactly on the central line of totality:

The plan of operations was to determine the epochs of the four contacts, to sketch the corona, and to look for Vulcanites. We have observed the four contacts and sketched the corona, the brightest circle concentric with the sun, and the sun flames. Before the first contact the sun's limb was very sharp and steady, with occasional shiverings, but exhibiting no spurious disk, such as would appear from great atmospheric disturbances. The three groups of sun-spots and their peculiarities, and even changes of detail, were constantly well defined. The "rice" mottling of the whole sun's disk was distinctly made out in all the telescopes and the conformation of the faculæ faintly traced. Using a solar eye-piece and high power, I obtained the first contact earlier than the other observers; but it was observed by all. The epoch of observed contact is within a second of time of the prediction. The transit of the moon's disk over the sun-spots was also observed in each telescope. During the progress of totality I called the observers' attention to the fact that there was a perceptible difference in the darkness of the sky, or background adjacent to the sun's disk, yet unobscured, compared with that immediately adjacent and covered by the moon's disk projecting beyond the sun's disk. And yet no one of us was able to perceive the moon's disk approaching the sun before first contact.

In watching and studying the sun's cusps, their points were remarkably acute, except at those times when the atmospheric disturbance increased so as to create the slight "shiverings" of the outline or of the spots; then the fine points of the cusps were duplicated apparently at a greater or less distance apart. This was recorded and drawn by Assistant Colonna and myself. With excessive atmospheric disturbance this apparent motion would have increased and the points would have been seen obtuse and blurred. On the moon's limb, and especially at and near the cusps, the mountains of the moon, projecting beyond its general outline were plainly visible and noted as breaking the circular outline of the disk, and similar inequalities could be traced throughout its whole extent. Toward totality a few cirrus clouds formed in the line of the sun and the atmospheric disturbance was at times increased.

As totality rapidly approached the crescent of sun light was remarkably narrow and long, on account of the slight difference of diameters of the sun and moon. The last line of light was from 30″ to 40″ in length before it broke. But the crescent exhibited no distortion from atmospheric disturbances, and no wavy movement, except occasionally that slight atmospheric disturbance which I have designated as "shivering," and which is seen at times in our geodetic observations. The cusps were remarkably sharp, with curved points, as if cut by the finest graver. The breaking of this extended curved line of sun light was on account of the lunar inequalities of outline, and presented the appearance of a line of irregular dots, dashes, and spaces. There was no wavy motion to occasion this appearance; whenever one point disappeared it was "gone for good." I did not remove the colored glass in observing this phenomenon (as I had done in 1869 in Alaska), because I wished to preserve my eyes for any possible Vulcanite. But I saw at once that, on account of the contracted diameter of the cone of shade, the illuminated atmosphere all around it rendered the sky too bright for this purpose, and I fixed my attention upon the position and extent of the red flames and the first circle of bright light around the sun, whilst others sketched the corona. There was a brilliant red flame just to the left of the sun's vertex, and the lower part of the moon's disk, say one-third of the sun's circumference, was bordered by a remarkably brilliant and continuous line of red flames. The concentric circle of bright white light around the sun was very striking. Sub-Assistant Dickens noted and sketched a second but fainter concentric circle. The corona had the general form of a parallelogram, with the angles prolonged in the direction of the longer sides, and stretched at an angle of about 3.° with the vertical from the upper left to the lower right of the sun. The outlines and general features of the corona are quite consistent among the different sketches, and in addition to the originals I shall have colored a special sketch for my report. Assistants Gilbert and Colonna obtained the third contact, or the ending of totality. The total phase lasted about thirty seconds.

The fourth contact was observed with the sun estimated at about 1¼° above the horizon, and immediately over the sea bank of clouds. The dip of the horizon was 1′ 12½″. Here the atmosphere was remarkably disturbed and unsteady, and the limbs of the sun and moon moved in great rapid waves, so that it was next to impossible to note in the smaller telescopes when the moon left the sun. This epoch was observed by myself later than it was by the others, but with no satisfaction, except as being approximately close. The sun set about eleven minutes later. Observations for temperature were made during the progress of the eclipse, and also with the thermometer for solar radiation, which fell from 68° to 28° Fahrenheit at totality.

Jupiter and Mars were seen by the observers several minutes before totality; no stars were seen by any observer. Before totality we all saw the shadow of the eclipse coming over the ocean; and after totality the shade of the cone was observed against the sky over the eastern mountains, but the shadow on the mountains themselves could not be made out on account of the dim light, the sun being on the horizon behind clouds.

This eclipse is another confirmation of the theory that the exhibition of Baily's beads, the ligament and black drop in the transits of Mercury and Venus, the hanging of a colored star on the moon's bright disk at occultation, and similar phenomena, are the consequences of atmospheric disturbances occasioned by irregularities, etc., of refraction. This view has been strongly controverted, but we have analogous phenomena exhibited every day in the geodetic observations of the Coast and Geodetic Survey. At high elevations, and during a remarkably steady atmosphere at any elevation, all these abnormal conditions vanish.

As a spectacle this eclipse in some respects exceeded, and in others was inferior, to that which I observed August 7, 1869, in Alaska. Here the red flames and the inner circle of white light were perfectly glorious, and the corona more brilliant, but the disk of the moon did not stand out with that full blackness and perspectic effect which was seen on the Chilkaht. The sky at Santa Lucia was much brighter, on account of the relative smallness of the cone of shade. The shadow upon the ocean surface was a poorly defined brown area; in the valley of the Chilkaht the coming of the shadow on the mountain flanks and snow gorges was more distinct and striking.

CONSTIPATION VIEWED AS A DISEASE PER SE, AND AS AN EXCITING CAUSE OF DISEASE.

By Robert Bell, M.D., Physician to the Glasgow Institution for Diseases of Women and Children.

It is my intention in this communication to bring under the notice of the profession a *casus morbi*, which I venture to say, although it is hardly ever overlooked, does not, as a rule, receive the attention it deserves; and, consequently, it might very often as well be ignored altogether as have bestowed upon it the passing notice so frequently accorded it. My observations extend over a period of six years, and the cases quoted are selected from a list of over two hundred. It does seem strange to meet with individuals almost daily who have been under treatment for weeks and months, and in many instances for years, and all this without any relief being experienced, when a little judicious treatment at the commencement of the symptoms of prostration might have prevented much of the suffering that has ensued, and have afforded speedy relief.

If we remember the power that the colon possesses of absorbing fluids (which numerous experiments place beyond a doubt), we do not require to ask an explanation as to the disappearance of the watery constituent of the stools in subjects suffering from constipation. I have heard it stated by a lecturer on the practice of medicine, that "it was quite compatible with health to go a week, or even longer, without having an evacuation of the bowels"—that, in fact, it was all a matter of habit. Now, my observations go entirely to disapprove such statements; moreover, such remarks are most apt to lead a student to look upon constipation as quite a trivial matter. If he does so, he will doubtless find that he has a great deal to unlearn, as he will soon discover that quite a host of complaints in every period of life may directly or indirectly take their origin in this abnormal condition of the bowels, and in very many instances the symptoms, as a whole, can be shown to be dependent upon this morbid condition. How is it that a smart purge, and a thorough clearing of the *primæ viæ*, have such a beneficial effect when one is feeling out of sorts? One rarely begins the treatment of any disease without being first satisfied as to the state of the bowels and endeavoring to rectify them. A purgative will probably be given if there is constipation, and yet in numberless instances purgatives may be given over and over again without having the effect of clearing away scybalous masses from the lower bowel. When constipation has continued for a lengthened period, the colon becomes distended, and the saculæ attain a greater capacity. The gut loses its tenacity, and consequently its power of contracting upon and expelling the fæces is reduced very materially. Thus we find that patients, when asked if they have a motion of the bowels every day, though they may insist that they are quite regular in that respect, yet, on close questioning, are led to confess that they never experience that sense of complete relief which they would wish to feel after a stool, but, on the contrary, that there is a desire to sit on the w.c., and endeavor to void more fæces. It will also be found that such individuals always complain of the fæces being lumpy and difficult to pass. Others again will inform you that, so far from their bowels being constipated, they have frequent attacks of diarrhea, but it will not be difficult to discover that such attacks are invariably preceded and followed by constipation; moreover, that the diarrheal evacuation contains hard pieces of feculent matter often described as pellets. How are these little attacks of diarrhea to be accounted for? That it is not diarrhea in the ordinary sense of the word is not difficult to show, as the stools are small in quantity, and do not come away with the rush that is generally a symptom of diarrhea in its true type. This form of diarrhea occurs most frequently early in the morning, often necessitating the patient rising out of bed and going to stool; indeed, there is no choice, as the desire is so urgent. There may be two or three such stools before breakfast, and the probability is there will be no more during the remainder of that day. Another characteristic of these stools is that they possess an extraordinary offensive odor. It is quite evident that what we have to deal with at present is a "looseness" of only a limited portion of the intestine, and is due to the irritation produced by the presence of hard masses of scybala in the colon, which act as an irritant on that portion of the bowel and produces a catarrh in their immediate vicinity; the mucus which is excreted from the mucous membrane then acts as a partial solvent to a portion of the scybalous matter, at the same time a partial disintegration of it takes place; and so we find that the stools in this intermittent kind of diarrhea always contain innumerable small pieces of hard fæces. In such attacks it must, of course, be worse than useless to employ the ordinary treatment of diarrhea by opiates or astringents. The removal of the cause must be aimed at, and hence the importance of a correct diagnosis. It will be generally admitted that when the fæces descend into the colon they are of a soft consistence; that they are *not* hard and dry. What has become, then, of their watery constituents when they are converted into hard scybalous masses? Sometimes so difficult to pass are they, that an evacution of the bowels in such circumstances may actually produce more suffering than the pains of labor, and, as I saw only a few days ago, may really bring on premature parturition. I would repeat, what becomes of the watery portion of the fæces, and what is the effect on the general system, especially the nervous apparatus, of the hardened matter lodged in the bowel? We have not to look far for an answer to the first part of the question, when we are cognizant of the power of absorbing liquids which the large intestine possesses. The fluid most certainly finds its way into the blood, and thus, of necessity, produces a form of blood-poisoning. We may note the following effects produced by the absorption of such fetid matter—the red corpuscles become diseased, they are altered in color, diminished in numbers, have their carrying power lessened. Thus a sallow complexion results, dark rings appear below the eyes where the skin is thin and more transparent, the limbs and extremities are cold in consequence of oxygen being supplied in less quantity. There is a feeling of lethargy due to the blood being vitiated and the corpuscles being in this enfeebled state. Consequently the system is not nourished, and there is a falling off in flesh. Then there is a diseased blood supply, circulating through the nervous system, and, as a consequence, nervous depression coexists. The pulse becomes slow and easily compressed. There is a feeling of numbness in the extremities, the organs of digestion and assimilation are lowered in tone. There is loss of memory, and a want of power of concentrating the thoughts, a heavy drowsiness supervenes, which never seems to be removed by what appears to be really sound sleep, and all the functions of the body are carried on in an unsatisfactory way. We will find, too, that the patient is tired on very little exertion of any kind. Then there are numerous local symptoms produced by the presence of scybala in the colon, which very often are attributed to other causes. Among these may be noted most acute pain on pressure over the situation of the hardened matter, and so severe may this be that it may simulate peritonitis. If it occurs in women we often observe, as a consequence, ovarian neuralgia, this being excited by the irritation conveyed to the ovary by the presence of scybala in its immediate neighborhood, while a predisposing cause exists in the lowered nervous tone consequent upon blood-poisoning. Frequently there is acute pain complained of over the ileo-cæcal valve, and in many, if not the very great majority of instances, typhlitis is a direct consequence of the irritation produced by scybala lodging in the cul-de-sac. Irritability of the bladder is another local symptom frequently resulting from a similar condition of things in the immediate neighborhood of the organ. Displacements of the uterus may be and are caused by large accumulations in the rectum, and in every case are very much aggravated by such a state of matters. I have seen cases where an accumulation of this kind has been mistaken for pregnancy, and at other times where it has been looked upon as an ovarian tumor. A very constant effect of this condition is the prevention of refreshing sleep at night. The patient always complains of dreaming, and nightmare is a frequent symptom of this torpid state of the bowels. It will invariably be ascertained that there is no refreshment from sleep, in fact the remark is generally made that he or she is more tired in the morning than they were on going to bed. In many cases I have found the temperature of the body rising at evening and falling again toward morning, so much so that typhoid fever has been suspected to be present. If children are the sufferers, a whole train of ailments may result, an idea of which will best be formed by a perusal of the report of cases given below.

In a most careful perusal of the most recent works on the practice of medicine, I cannot find in one of them the subject of constipation gone into *per se*, and even where it is mentioned as a concomitant of other diseases, it is barely glanced at. This is all the more strange when it is beyond doubt not only a disease having a most enormous train of painful symptoms, but is a predisposing cause of quite a host of other ailments.

In illustration of the foregoing remarks I append a series of cases, commencing with the youngest:

Case 1.—Mrs. J——'s baby, aged nine months, has been for some nights suffering acute pain, as evidenced by crying most bitterly, and kicking for hours at a time, and there was also a considerable amount of fever; but as the symptoms always subsided toward morning, some days were allowed to elapse before I was sent for. I ascertained that the following symptoms had been remarked by the mother and nurse, besides those enumerated above: If by chance the child fell asleep, it invariably wakened with a start, and began to shriek as if in pain. There were frequent evacuations from the bowels, and latterly a good deal of mucus, mixed with small pieces of feculent matter, had been voided. Moreover, the child began to fall off in flesh, and it was when this manifested itself that I was sent for. I observed the child had a blanched and sallow physiognomy. The abdomen was very much distended, and it was ascertained that there had been pretty constant vomiting after taking food. One would naturally suppose that such a train of symptoms pointed clearly to some head mischief, and I cannot help thinking that, in many cases of supposed hydrocephalus in children, the symptoms are due to no more than an accumulation of scybala in the colon, the presence of which acts as a direct irritant to the nervous system. The treatment consisted in giving an enema of salt and water—two teaspoonfuls of the former to a teacupful of the latter, the good effect of which was manifest in a few hours, and the infant had a refreshing sleep after the enema had acted freely. This was the first satisfactory sleep the child had had for several days. No other remedies were called for. It may be remarked by some that a dose of castor oil would have had quite as good an effect, but it had been tried more than once without giving any prolonged relief, although it acted upon the bowels. I have often seen this happen, and I can only explain it in this way, that the scybala lie impacted in the saculæ of the colon, and are not dislodged by the action of the oil, the matter removed by the oil simply passing over the accumulations of hardened fæces. In this case there was observed the anæmic look, falling off in flesh, flabby condition of the muscles, starting during sleep, fever at night, etc., all of which symptoms disappeared when the irritant was removed.

Case 2.—F. M——, aged three, had prolapsus of the rectum, induced by a prolonged constipated condition of the lower bowel, but the prolapse was attributed by the mother to the boy's health having become deteriorated, whereas the ill-health was consequent upon the same cause as the prolapsus. The fact was elicited that the nurse had not been attending to the state of the child's bowels, and they had become so constipated that the little one shrank from going to stool because of the severe pain it produced. Coincident with this the boy's health began to fail. He was losing flesh, became feverish toward night, was restless, and started up during sleep, and throughout the day was listless and easily fatigued. At the same time his appetite was very fitful. It was the above symptoms which led to the conclusion that the prolapsus was due to the difficulty and consequent straining accompanying a motion of the bowels. An enema was ordered to be given every second day, and within a short time the child's health was completely reestablished.

Case 3.—My own boy, aged six, gradually began to lose flesh, and became very lethargic and easily fatigued. There was also a feverish condition at night, and sleep was always disturbed by starting, and sometimes a species of delirium would come on for a period varying from a few minutes to an hour or so during the night. He was drowsy and irritable, and cried on the least provocation. There was also loss of appetite and failing strength. The bowels acted every day, and seemed to be in very fair order. On examining the stools, however, they were found not to be sufficient in quantity, and were not soft enough in their consistence. He had an enema of salt and water, which brought away a large evacuation of hard fæces, and within a very few hours a decided improvement was observed in his health. He had all the appearance as if a heavy load had been lifted off him. He slept well the following night, and very soon regained his wonted health and spirits. This was all the treatment adopted. It may here be remarked that mothers

and nurse-maids are very apt to be put off their guard when the condition of the child's bowels is being inquired into. The answer will frequently be given that the patient is quite regular in this respect. In fact, one is often informed that "the little invalid is very regular indeed," having often "more than one motion in the day." Now this is always a suspicious circumstance, and requires close attention. The stools should be examined, and we will almost invariably find that they are very small in quantity and of very hard consistence. Inquiry will further bring out the information that the child inclines to sit at stool and strain for a long time after having had a motion. This is because the rectum is not completely emptied, and the reason of the frequent small stools is due to the same cause. Another effect of this, more especially in boys, is an inability to retain the urine for any length of time, and thus in many instances we may account for the habit boys so frequently have of wetting the bed during sleep.

CASE 4.—J. P——, aged twelve, a girl, tall of her age, very thin and anæmic. She complains of being languid and easily tired, and inclines to lounge about all day. Naturally she is a sharp and intelligent girl, and is fond of her books, but for the past few weeks she does not care for her lessons, and altogether is quite changed in her demeanor. She inclines also to lie still in the morning instead of rising at her usual hour, and always expresses herself as "feeling so weary." Her sleep at night is very much disturbed by dreams and nightmare. Her appetite is variable. The bowels are very costive, and she confesses that she has been in the habit of putting off going to stool when she has felt the desire to go. She also complains of pain at times over the right iliac region, which is tender on pressure.

The treatment consisted of an enema of salt and water every second night, which speedily removed all the symptoms, and a rapid restoration to health was the result.

CASE 5.—M. P——, aged sixteen, presents a chlorotic appearance. She is very weak, and is changed from being a lively and active girl into one of languid, lethargic, and desponding appearance. She is irritable and hysterical. Her sleep is broken, and in the morning there is no refreshment from sleep, and, in consequence, there is a wish to lie still in bed, and a disinclination to perform any of the duties she used to enjoy attending to. She very speedily becomes breathless on moving about, and complains of an inability to walk even a short distance without it entailing great fatigue. The extremities, especially the feet, are hardly ever warm. The menses are regular, but the amount of discharge is much less than usual. The bowels are costive, and, on inquiry, the patient says that when she has a stool there is a feeling that the relief is not complete.

The treatment consisted of an enema containing a tablespoonful of salt in one pint of tepid water every second day. In a few days there was a marked improvement in all the symptoms. Bland's pills were also prescribed, and in three weeks the girl was quite restored to her usual color and active health.

CASE 6.—Miss R——, aged twenty, a healthy-looking country girl, came to town to be treated for dysmenorrhœa, which had caused her intense suffering for close upon three years, and which was growing month by month more severe. The patient was very hysterical, and her mother informed me that she was low-spirited and irritable in her temper. She was gradually becoming less able for the least amount of fatigue; and however much sleep she might obtain, it never was followed by a feeling of refreshment. Her digestion was very much impaired, and she complained of cold feet, and there was a tendency to shiver even when the temperature was high.

As the dysmenorrhœa was so severe, all the above symptoms were attributed to this, and I was inclined to indorse this view before I had made a vaginal examination, but, on passing the finger into the vagina with the object of guiding the uterine sound, I found that the rectum was loaded with scybala. In consequence of this discovery, my opinion as to the *casus morbi* became considerably modified, and I was inclined to attribute, if not *in toto*, at least to a very considerable extent, many of the symptoms to this sluggish condition of the bowel, instead of to the dysmenorrhœa. No doubt the uterine affection had a very powerful influence on the girl's bad health; at the same time, when we know the disastrous effects of constipation—rendering, as it does, the nervous system highly susceptible of morbid impressions, besides acting in this instance as a direct irritant to the womb, in consequence of the close proximity of the hardened fæces to the organ—we dare not ignore this morbid condition of the bowel in considering what the factors of disease were in this case. Moreover, it was ascertained that constipation had troubled the patient for a longer period than the dysmenorrhœa had, and she informed me that she rarely felt completely relieved after she had been at stool.

The treatment consisted in having the uterine sound passed bi-weekly; and an enema of a tablespoonful of salt to a pint of tepid water was ordered to be used every alternate day.

Before the monthly period came round her health was decidedly improved, so that the improvement could not be due to any alleviation of the uterine disorder. After about six weeks' treatment she went home, quite recovered. It is now nearly two years since the treatment was carried out, and I understand there has been no return of the dysmenorrhœa, and the young lady's health is otherwise all that can be desired.

CASE 7.—Mrs. S——, aged twenty-six, is a highly nervous lady, who can hardly speak without bursting into tears. She complains of great prostration and want of energy. She sleeps pretty well, but never feels refreshed in the morning. She is troubled very much with dreams and sometimes with nightmare. The patient is very low-spirited, and takes a very gloomy view of life. There is little or no appetite, and when she does eat she always wishes she had not done so, as there is so much discomfort after a meal. She is losing flesh, and complains of palpitation of the heart, severe frontal headache, bad taste in the mouth (especially in the morning), severe pain over the lumbar region, and a bearing-down sensation "as if her inside were coming down." Her pulse is very feeble. She says her bowels are very costive, and, though her menses are regular, there is always severe dysmenorrhœa.

A vaginal examination reveals retroflexion of the uterus and the rectum loaded with hardened fæces which are pressing on the fundus of the uterus and actually tending to hold it in its abnormal position. The womb measures three inches, and its walls are soft and flabby. My impression on making the examination was, that the constantly loaded condition of the rectum was really the cause of the malposition of the organ, as the patient had never been pregnant, and the walls of the uterus were flaccid and, therefore, more easily bent out of position.

While attending to the uterine ailment, I ordered an enema of salt and water to be used every alternate day, which gave the greatest possible relief to the patient, and she gained strength so rapidly that at the end of three months she expressed herself as feeling perfectly well.

It would be quite possible to go on quoting cases almost *ad infinitum*, all of which would demonstrate the baneful effects of constipation; but I trust that the few I have selected will be sufficient to direct the attention of the profession more particularly to this morbid condition, which proves itself not only to be a most distressing disease, but is the superinducing cause of so many other disorders. It will be observed that I have not related any cases of adult males who have been treated by me for this affection, but it is not because there is a paucity of such cases, for although females are much more prone to this disease and suffer more from it than members of the male sex, yet one often meets with constipation in men which not only itself produces a whole host of distressing symptoms, but when allowed to go on unchecked, helps to develop what but for it might still remain latent disease. I do not happen to have notes of such cases, but I can recall to my mind quite a number of instances where constipation was really the cause of great mental depression, irritability of temper, and weakness of body, these all being attributed to want of tone, but which speedily disappeared when enemata were regularly employed to keep the bowels in a state of action.—*Lancet.*

ALBUMINATE OF IRON—ITS PREPARATION AND USE.

DR. W. DONITZ, of Tokio, Japan, in the *Berlin Klin. Wochenschrift*, gives the following directions for preparing it:

The whites of one or two eggs are beaten up with about five ounces of water, while six drops of solution of chloride of iron of the German Pharmacopœia are dissolved in an ounce of water, in another vessel. The iron solution is then added gradually to the albumen, the mixture being continuously and vigorously stirred meanwhile. At first the mixture is cloudy, but by thorough stirring it becomes almost or quite clear. The cautious addition of a few drops of hydrochloric acid clears up the solution, but this is hardly necessary if the stirring process has been well carried out. When the solution is cloudy or contains clots of albumen, it may be easily filtered. The filtered fluid is brought up to six ounces, so that a tablespoonful will contain one-half drop of the iron solution. For convenience of dispensing the albuminate of iron, it may be dried into thin scales and powdered, since it is easier to dissolve this powder in water than to prepare a fresh supply of the moist albuminate. Dr. Donitz has employed this preparation for the past two years with great satisfaction. It can be given in cases where the stomach is so weak that no other preparation of iron is tolerated. The dose is a tablespoonful thrice daily. Hypodermically, Dr. Donitz has given the preparation in doses of one-eighth of a grain or more, in an ordinary syringeful of solution, of which one-half was injected in one locality and the other half in another, at one time.

THE HEREDITARY EFFECT OF EXTIRPATION OF THE SPLEEN.

MASOIRE removed the spleen from a male and female rabbit. After the healing of the wound, both of the animals, apart from each other, were used for breeding. In order to learn the hereditary effect of extirpation of the spleen in this way, the progeny of these animals for several generations must be deprived of their spleens. We may look, with a considerable degree of certainty, for the gradual diminution of the spleens in the various generations, which possibly may lead to complete loss of the spleen. In his first communication on this subject, Masoire reports the results in three rabbits of the first generation. In all three the weight of the spleen, relatively to the body weight was diminished one-half. Similar weighings of the livers of these three animals presented no apparent difference from the normal weight; the imperfect formation of the spleen had exercised no influence on the development of the liver. Through these first experiments the author established his propositions. By continued breedings their correctness was still further proven.—*Med. Newigk.*—*Cincinnati Lancet.*

BURNS AND SCALDS.

THE following application is quoted from German sources, in the *American Journal of Pharmacy:*

℞.	Iodoformi	ʒ ij.
	Extracti conii	ʒ ij.
	Acidi carbolici	gtt. x.
	Unguenti aquæ rosæ	℥ ij. M.

SIG.—spread on lint, and apply to the parts twice daily.

Dr. R. E. Howard (*Medical Herald*, Nov.) recommends a *saturated solution of sulphate of magnesia*, applied on lint, and small doses of it internally. In a severe burn from concentrated lye, he says he never saw a remedy act more promptly and satisfactorily.

THE ODOR OF THE SOUL—GERMAN PHILOSOPHY.

THE Berlin *Gegenwart* of November 15 contains a report of some interesting experiments made by Dunstmaier to test the accuracy of Jager's theory that the soul of every man and animal is to be sought for in the characteristic odor exhaled in each case. Dunstmaier, who unites in his own person the physiologist and metaphysician, was, until these experiments convinced him of his error, an outspoken opponent of Jager's views. He is now, however, an enthusiastic convert. Dunstmaier's method was no doubt suggested to him by his familiarity with experimental science. He considered that light and soul—if the soul is an odor—are both radiated, and that light can be, as it were, collected and fixed by a photographic plate coated with iodide of silver. What body, now, is as sensitive to odors as iodide of silver is to light? Evidently the nerves of smell in a dog. In the center of the laboratory a cage containing twenty hares was placed, and a dog was admitted to the room. He at once made violent efforts to get at the hares, which, of course, in their terror rushed to and fro in the cage. After two hours of this torture the dog was killed, the nerves of smell and the mucous membrane of the nose removed, and rubbed up in a mortar with glycerin and water. The twenty hares had been exhaling their souls for two hours, and the dog, during all his panting and snuffing, inhaling them for the same length of time. The glycerin might be expected, then, to contain a certain quantity of the soul of the hare, the main characteristic of which is, of course, timidity. That this was the fact the following experiments seemed to prove. A few drops of the extract were administered to a cat: she ran away from some mice instead of pouncing upon them. By the subcutaneous injection of only two cubic centimeters a large mastiff was rendered so cowardly that he slunk away from the cat. By a similar experiment, in which, however, a young lion in a menagerie played the part of the hares, Dunstmaier succeeded in isolating the soul-substance of courage and in transmitting it to other animals. Still more interesting experiments showed clearly that these "psychotypic" glycerin extracts had a decided effect on the human species. Thus, after swallowing a small dose of psychotypic timidity, Dunstmaier had not the courage to believe in his own great discovery! This effect soon passed off, however. On the other hand, Jager found a large dose of psychotypic courage of the greatest use while writing his last work on the Jews. Dunstmaier has published his investigations in the first volume of the "Transactions of the German Ozological Society," where our readers can also find the details of some experiments in which a timid, blushing girl was the original radiating body.—*The Nation.*

THE DECAY OF THE EMOTIONS.

IN reading history, one cannot but be struck with the decay of the emotions which has taken place in the last few centuries, say since the rise of national literatures. Men do not love or fear, hate or enjoy, with the violence they once did. The whole tone of modern life is against such emotional excess. We see in this age the charge of the Light Brigade through a valley raked by cannon shot; but the individual soldier is seized by no such fury as the *Berserkerwuth* of the Northmen. Men pursue their purposes with no less tenacity, and with undiminished unscrupulousness, but the passion of revenge, which played such a prominent part in the days of yore, is now next to obsolete. In the autobiography of Benvenuto Cellini, that great artist informs us that after an insult he was seized with a sort of fever or delirium, which could not be appeased until he had wreaked his resentment.

Many instances are on record of persons dying outright from grief, or joy, or disappointment, while nowadays such occurrences are extremely rare. Several such are recorded in the "Memoires" of the Marechal de Vielleville, a leading French general of the sixteenth century. On one occasion he had surprised and captured a young Spaniard who had charge of an outlying post. It was under circumstances of a nature to entail severe censure on the captive for carelessness.

Although unhurt and in good health, he died, of mere grief, the first night of his captivity. Examples are not rare where a courtier forbidden the royal presence presently died of mortification. They seemed less able to hold out against moral reverses than now.

It is evident that to-day men are less apt to act on impulse than formerly. They weigh and ponder more. This powerfully affects their viability, and is unquestionably an important factor in the longer lives that modern generations have. With this comes a much greater tolerance of disease and of unhealthy surroundings. Less easily depressed, with more hope and better grounds for it, they do not yield to the depressing and often fatal effects of fear and despair.

Evidently, therefore, the decay of the emotions is a hygienic advantage. It means the increased power of the intellectual elements of mind. It is a sign of progress, and as closely associated with greater tenacity of life, is one which the physician should foster. In marked neurotic temperaments the control of the emotion is the most difficult lesson to learn, but is essential to safety. Self government is not attained until the actions are guided by thought rather than impulse; and the improvement of the individual or the race is conditioned on personal self government.—*Med. and Surg. Reporter.*

ON THE ARTIFICIAL FORMATION OF THE DIAMOND.*

By J. B. HANNAY, F.R.S.E., F.C.S.

PRELIMINARY NOTICE.

WHILE pursuing my researches into the solubility of solids in gases, I noticed that many bodies, such as silica, alumina, and oxide of zinc, which are insoluble in water at ordinary temperatures, dissolve to a very considerable extent when treated with water-gas at a very high pressure. It occurred to me that a solvent might be found for carbon; and as gaseous solution nearly always yields crystalline solid on withdrawing the solvent or lowering its solvent power, it seemed probable that the carbon might be deposited in the crystalline state. After a large number of experiments it was found that ordinary carbon, such as charcoal, lampblack, or graphite, were not affected by the most probable solvents I could think of, chemical action taking the place of solution.

A curious reaction, however, was noticed, which seemed likely to yield carbon in the nascent state, and so allow of its being easily dissolved. When a gas containing carbon and hydrogen is heated under pressure in presence of certain metals, its hydrogen is attracted by the metal, and its carbon left free. This, as Prof. Stokes has suggested to me, may be explained by the discovery of Profs. Liveing and Dewar, that hydrogen has at very high temperatures a very strong affinity for certain metals, notably magnesium, forming extremely stable compounds therewith.

When the carbon is set free from the hydrocarbon in presence of a stable compound containing nitrogen, the whole being near a red heat and under a very high pressure, the carbon is so acted upon by the nitrogen compound that it is obtained in the clear, transparent form of the diamond. The great difficulty lies in the construction of an inclosing vessel strong enough to withstand the enormous pressure and high temperature, tubes constructed on the gun-barrel principle (with a wrought-iron coil), of only half an inch bore and four inches external diameter, being torn open in nine cases out of ten.

The carbon obtained in the successful experiments is as hard as natural diamond, scratching all other crystals, and it does not affect polarized light. I have obtained crystals with curved faces belonging to the octahedral form, and diamond is the only substance crystallizing in this manner. The crystals burn easily on thin platinum foil over a good blowpipe, and leave no residue, and after two days' immersion in hydrofluoric acid they show no sign of dissolving even when boiled. On heating a splinter in the electric arc it turned black—a very characteristic reaction of diamond.

Lastly, a little apparatus was constructed for effecting a combustion of the crystals and determining their composi-

* A paper read before the Royal Society, February 26, 1880.

tion. The ordinary organic analysis method was used, but the diamond crystals were laid on a thin piece of platinum foil, and this was ignited by an electric current, and the combustion conducted in pure oxygen. The result obtained was, that the sample (14 mgrms.) contained 97·85 per cent. of carbon—a very close approximation, considering the small quantity at my disposal. The apparatus and all analyses will be fully described in a future paper.

The specific gravity of the diamond I have obtained ranges as high as 3·5, this being determined by flotation, using a mixture of bromide and fluoride of arsenic.

NEW PROCESS FOR ELECTROTYPING NON-CONDUCTING MATERIALS.

FOR electrotyping on non-conducting materials, such as china and porcelain, a new and ingenious process has been lately introduced in France. Sulphur is dissolved in oil of spike lavender to a sirupy consistence; then chloride of gold or chloride of platinum is dissolved in ether, and the two solutions mixed under a gentle heat. The compound is next evaporated until of the thickness of ordinary paint, in which condition it is applied with a brush to such portions of the china, glass, or other fabric as it is desired to cover, according to the design or pattern, with the electro-metallic deposit. The objects are baked in the usual way before they are immersed in the bath.

ANALOGY BETWEEN FLUIDITY AND GALVANIC CONDUCTIVITY.

O. GROTRIAN finds an interesting relation between the reciprocal of the constant of friction in fluids and the galvanic conductivity of a number of salt and acid solutions. Let t designate the temperature of the fluid, f the temperature coefficient of fluidity, and k the conductivity. Then the value of the coefficient, $\frac{df}{dt}\frac{1}{f}$ in a change of concentration, always alters in the same direction as the corresponding coefficient of conductivity, $\frac{dk}{dt}\frac{1}{k}$.—*Wied. Ann.*

ACTION OF WATERY VAPOR ON CARBON AT DIFFERENT TEMPERATURES.

By C. G. DAHLERUS.

As it is necessary, in order rightly to understand the occurrence of hydrogen both in furnace and generator gases, to have some knowledge of the temperature which is required for the combustion of carbon with watery vapor, and in general of the circumstances which influence the combustion in question, I undertook some months ago, at the request of Professor Akerman, to make some experiments on this point at the laboratory of the Stockholm School of Mines. These were carried out by passing watery vapor through a heated tube filled with charcoal, and by collecting and analyzing the gases that were thus formed.

A boiler of about 150 cubic centimeters capacity, provided with a small mercurial manometer, was used for producing the steam, which was passed through a tube provided with a stop cock for regulating the speed with which the steam passed into the tube filled with charcoal. This tube, which was 1·5 cm. in diameter and 1 meter in length, was placed in a combustion furnace 58 cm. long, and having twenty jets. The tube was so placed that, at the side where the steam entered, 16 cm., and at that where the gases were taken out 26 cm. of the tube were out of the furnace in order to protect the corks inserted in both the ends from burning. In order to determine the temperature inside the tube there were placed at three different points, viz., in the middle and at the distance of 15 cm. from either end of the portion of the tube within the furnace, trays of steatite containing pieces of Mayerhofer alloys with different melting points. These trays had each a length of 5 cm. The other part of the tube intended to be heated was filled with pieces of charcoal of such a size that they passed through a sieve with holes of 0·75 cm., but were retained by one with holes of 0·35 cm. The determinations of external temperature were made with a hydro-pyrometer, the ball being placed by the side of the iron tube, and the determinations always made when the ball had the same color as the tube. The velocity of the steam was in all the experiments so proportioned to the height of the gas jets by which the tube was heated that as much heat was conveyed to the tube as was carried away from it, so that the same alloy always remained unfused in all the three trays. The gases which were formed were led through a spiral gas tube in order to condense the steam, the tube being divided at its end into two, so that the water was conducted downward through a vertical tube into a graduated cylinder, while the permanent gases were led upward and collected in a graduated cylinder filled with water, or were received into an Orsat apparatus in order to be analyzed. As no sample of gas was taken until the experiment had lasted at least two hours, it is assumed that the content of atmospheric air found in some of the analyses has arisen from the air in the tubes and in the Orsat apparatus not having been completely removed, and the content of air has therefore been deducted from the analyses.

When watery vapor burns carbon to carbonic oxide, there are formed from two volumes of watery vapor two volumes of carbonic oxide and two volumes of hydrogen. Further, when carbon is burned by watery vapor to carbonic acid, there are formed from one volume carbon and four volumes watery vapor, two volumes carbonic acid and four volumes hydrogen. Consequently the volume of hydrogen in the gases ought to be equal to the volume of carbonic oxide and double that of the volume of carbonic acid. The gases have, however, as their smell indicated, always contained carbureted hydrogen, and in this way may be explained why the percentages of carbonic acid and oxide and those of hydrogen, calculated in the way just stated, do not always make 100.

The experiments were at first carried on in the following way. After the tube had been filled and the different parts of the apparatus connected together and the water in the boiler brought to the boiling point, the gas under the tube was lighted with as small a flame as possible, and afterward raised a little every half hour, until the heat was so great that combustible gas escaped from the tube, after which the jets were kept at the same height. After the experiment had gone on in this way for one or two hours, the pressure of the steam being kept as uniform as possible, samples of gas were taken, which were analyzed. During the same period, determinations of external temperature were made. Afterwards the experiments were made in a different way. After combustible gas had been obtained with the smallest possible flames and samples had been analyzed, the jets were raised somewhat at the expiry of each half hour. Between every raising of the jets samples of gas were taken and determinations of external temperature made. Finally, experiments were made in such a way that with the highest possible temperature the pressure of the steam was lessened until no water passed out of the tube in an undecomposed state. The results of these experiments are shown in the following table:

Number of the experiment.	Pressure of steam. Lines mercury.	Water condensed and collected. Cubic cm. per minute.	Combustible gas formed. Cubic cm. per minute.	100 volumes of combustible gas contained. CO_2 vol.	CO vol.	H (by calculation). vol.	Total gas. vol.	Temperature in Centigrade deg. External.	Internal.
1	2	0·4	0	—	—	—	—	400	400
2	2	0·33	10	30·7	3·6	65·0	99·3	500	450
3	2	0·23	10	25·3	10·6	61·2	97·1	500	450
4	1	0·05	2·5	24·3	12·0	60·6	96·9	500	450
5	0·5	0·00	1·33	21·6	16·8	60·0	98·4	500	450
6a	1	0·07	25	31·1	3·3	65·5	99·9	500	—
6b	1	0·07	33	26·3	8·6	61·2	96·1	675	—
6c	1	0·07	36	25·8	10·3	61·9	98·0	750	—
6d	1	0·07	60	24·2	11·6	60·0	95·8	800	—
6e	1	0·06	100	23·0	15·0	61·0	99·0	850	—
6f	1	0·05	300	21·6	15·5	58·7	95·8	900	—
7a	2	0·30	54	28·7	3·6	61·0	93·3	700	900
7b	2	0·27	150	25·1	12·3	62·5	99·9	750	—
7c	2	0·17	200	22·5	15·3	60·3	98·1	900	900
8	1	0·05	170	15·8	26·3	57·9	100·0	900	900
9	0·5	0·00	160	14·2	28·6	57·0	99·8	900	900

On examining this table it appears that watery vapor is decomposed at a temperature which is indicated by the alloys as from 450° to 500° C., but the temperature may, in fact, not have been higher than 400° C., because zinc in the interior of the tube was not fused in any of the five first experiments. Further we see that the greater the excess of watery vapor the richer in carbonic acid are the gases; or in other words, that carbonic oxide is very easily burned to carbonic acid by means of watery vapor, and that the content of carbonic oxide is increased both by a lessened excess of watery vapor and by the raising of the temperature, and that the best gas is thus obtained by raising the temperature as high as possible and by a moderate supply of steam.

In connection with this some experiments have also been made to determine the temperature at which carbonate of lime begins to give off carbonic acid. These experiments have shown that the carbonate of lime begins to become caustic at a temperature which, as indicated by the alloys named, lies between 550° and 600° C.; but that pieces of the same size as that of the charcoal employed in the former experiments, when heated in a current of air of 900° C., did not become completely caustic after the lapse of six hours.

TREATMENT OF HORSES' LEGS.

THE management of horses' legs forms a part of the science of the stable, and a most important part too. It is nowhere so well understood as in trotting and racing stables; but from the violent nature of their work, the occupants of these stables are especially liable to ailments of the limbs. The barbarous practice of blistering all fore-legs previously to turning out is getting into disuse. Without stating the extent of the injury, it is useless to talk of prescribing remedies; and we have only to state that a very efficient one has been found for the torturing and blemishing one of firing, in many cases where this was considered as the only remedy. For example, for ligamentary enlargements, cases of enlarged joints, tendons showing symptoms of giving way, or any other appearance in the limbs of a departure from their primitive tone and vigor. This consists in the application, during any period of rest, of the mercurial charge, in the following form: It consists in the common mercurial *plaster* (not ointment), and in the proportion of half a pound to a leg, applied in a warm and consequently liquefied state, and then covered by cow's hair, bound to the limb by means of a linen roller. At the end of a fortnight, the stitches of the bandage being decayed, the charge will slough off, when an other, if necessary, is put on. It is to the highly absorbent property of mercury that the benefit here derived is to be ascribed; and it is no small recommendation to it that, in addition to the general restoration of the limb, the painful operation of firing, as also the blemish occasioned by it, are avoided.

It is, however, a well-known fact, that horses will work and stand sound, for many successive seasons, with legs apparently much out of form. Enlargements take place in the sheath of tendons after strains; also from blows, where the parts become linked by a thick coat of lymph; and sometimes the body of the bone itself is found thickened, from a deposition of bony lamina over the original bone. When all this has been in progress, we question the propriety of any active measures, unless, as is generally the case, a feeling of soreness is expressed after work, by a shifting or favoring of the limb or limbs in the stall; or by a "feeling" manner of going on first quitting the stable. When legs are really callous, little impression can be made upon them, unless by active measures; but physic, rest, and good grooming, are the best preservatives of these most essential members of the horse's frame; with the friendly auxiliaries of hot water fomentations, flannel bandages, and loose boxes, after severe work, and good shoeing at all times.

A NEW CLASS OF ROSES.

THE year 1879 has given us, in the roses raised by Mr. Bennett, a new class which is likely to create greater interest than any roses, perhaps, which have ever been brought before the public. I do not mean that they will supplant the classes already known, or that they will prove of greater value than those we have. This may come to pass, in a measure at least, but as these hybrid teas of Mr. Bennett have only been partially tested, and that in England only, their definite position and value is yet unproved. They are, however, all pedigree roses, and any one in examining their parentage must conclude that very desirable varieties are likely to be had from such crosses.

In 1867 there was sent out by Mons. J. B. Guillot, of Lyons, France, a rose which is the sweetest, and probably the most popular, of any rose grown. This sort came up in a mixed bed of seedlings, sown from pods of various tea roses. It was soon remarked that this variety differed greatly from the teas in the same bed, though evidently having a strong infusion of tea blood; it was named La France, classed among the remontant roses, and soon proved itself worthy of a national name. Though a chance seedling, its parentage unknown, it is the head of that class of roses now known as hybrid teas. Mr. Bennett has adopted the course of manual fecundation with roses, fertilizing different tea roses by several varieties of the hybrid perpetual; the parentage of all his seedlings is therefore known, and adds greatly to the interest of the result.

The parent plants of the roses sent out by him in 1879 were the teas *Alba Rosea*, *President*, and *Mme. de St. Joseph*; these were fertilized by the remontants, *Countess of Oxford*, *Louis Van Houtte*, *Duchess of Vallambrosa*, *Marquise de Castellane*, *Lord Macaulay*, *Emelie Hausburg*, *Mme. Victor Verdier*, *Countess of Serenye*, and the moss *Soupert et Notting*.—*H. B. Ellwanger, in Country Gentleman.*

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